SMALL MAMMAL POPULATIONS IN CLEARCUT AREAS OF THE JACKSON DEMONSTRATION STATE FOREST, MENDOCINO COUNTY, CALIFORNIA

A TECHNICAL REPORT FOR THE
CALIFORNIA DEPARTMENT OF FISH AND GAME
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ABSTRACT

In order to investigate successional changes, small mammals were live-trapped during three winter and three summer months of 1990-91 in Coastal Redwood-Douglas-fir stands of the Jackson State Demonstration Forest. Five clearcut sites of ages two, four, seven, 11, and 27 years that had been allowed to revegetate naturally were examined, as well as an 80-year-old stand that represented an unlogged control. Sixty live traps of two sizes were set in a randomized pattern in each site during each of the six trapping periods. Data on vegetation and other site factors from a companion study of succession were utilized to determine how the various species were correlated with habitat characteristics.

Of the ten mammalian species captured, four were much more abundant than others, in this order: Deer Mouse (*Peromyscus maniculatus*), California Red-backed Vole (*Clethrionomys californicus*), Dusky-footed Woodrat (*Neotoma fuscipes*), and Sonoma Chipmunk (*Tamias sonomae*). Chipmunk populations peaked in year two, and were correlated with three measures of woody debris. The Deer Mouse had high population levels in the four youngest sites, and correlated with early to mid-age site factors. Woodrat populations peaked very strongly in age seven and were moderately high in ages four and 11, strongly correlating with the vegetative site characteristics of these mid-aged stands. This species was absent from the 27-year-old pole timber stand and in the Control. The Red-backed Vole had very low population levels in the three youngest sites, but high levels from age 11 on. It correlated with cover of larger conifers.

By various measures, small mammal diversity was 2-3 times higher in the younger clearcuts through age eleven than in both the 27 and 80-year-old stands. Total captures were twice as high in the first four ages than in the last two, while live-weight biomass peaked in the seven-year-old stand to a value 6.6 times greater than that of the mature forest. We have concluded that small mammal diversity, total numbers, and total biomass will be high in naturally revegetating clearcuts until the canopy of conifers approaches complete closure. As stands of conifers mature, these measures decline markedly.

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INTRODUCTION

In order to learn more about the populations of small mammals in its different management subunits, the Jackson Demonstration State Forest entered into a contract with the California Department of Fish and Game for a one year study. We performed this work under a cooperative agreement between CDFG and the Sonoma State University Academic Foundation, Inc. Our purpose was to learn how the relative abundances of the small mammal species changed as clearcut sites went through the process of revegetation. The existence of a variety of sites of known age made it possible to select stands that represented a time trend of approximately 80 years, providing information that could be applied to analysis of the long-term affects of logging on small mammal populations and the other species that depend upon them.

We define "small mammals" operationally as all mammals that can be captured with seed and fruit-baited live traps of rat-size or smaller. The species that fall under this definition include rodents and insectivores, excluding the strictly arboreal or fossorial forms. Previous work in JDSF was limited to a 1963-64 in-house survey of two areas. Though not extensive, data from the study did show that small mammals are common in the forest. We wanted to capture and identify all of the species on the sites we selected, and therefore sampled each of them a total of six times during both winter and summer. Obviously, one can never know from a single study if all species have been found, but efforts undertaken here provide the foundation for a comprehensive understanding of small mammal diversity in the Forest. Our contractual obligation was to obtain small mammal data in JDSF in such a manner as to relate them to the time-trends of forest succession. This associative effort involved use of data on the plant communities and other site factors gathered in a companion study currently being performed by Dina Rivas, a graduate student at Sonoma State University working under the supervision of Dr. Chris K. Kjeldsen.

Presentation and analysis of the data on small mammals were our main purposes, not a review of the literature on the species. Nonetheless, we have included some interpretation of the results as they compare with other published information. A more systematic analysis from the biological literature will be reserved for the Master's Thesis of Mrs. Fitts, a copy of which will be provided to both CDFG and JDSF. We have included several appendices so that our data will become part of the permanent record for JDSF.

METHODS

Site Selection

Six sites that represented stands of different ages were selected using criteria to assure that time-since-cutting ("age") was the primary site variable. Only one suitable site existed representing an age of approximately ten years (Hare Creek '80). Since this was an especially important age for showing trends, other sites were selected that matched its approximately north-facing aspect and moderate slope. For all study sites, two other criteria were applied: (1) sufficient acreage to obtain an accurate measure of plant and animal species within the body of the site, and (2) revegetation by natural ecological succession after the initial treatment. In the ideal, this last criterion meant that no application of thinning, burning, or other treatment that might have altered the character of the site was applied except immediately following the cut. Some exceptions to this last criterion existed, but they were not deemed to have had major affects on succession. All of the sites had some tree planting, but were primarily revegetated by natural processes. The six areas were a control site of maturing coniferous forest and sites of five other ages, designated by the year of logging. Specific information about the sites is as follows:

> The 1989 Site (Caspar East '89, Unit J, Age 2): This 43 acre site with an average slope of 33 percent was clearcut by cable and tractor. Landing slash was piled and burned in the summer of 1991, but slash remained on the ground as the dominant feature of the rest of the site. Small resprouts of Redwoods (*Sequoia sempervirens*) and several shrub species were present. Redwood seedlings were planted in February of 1991.
>
> The 1987 Site (Peterson Gulch, Unit B, Age 4): This 27 acre site was yarded and tractor-logged in 1987. It was dominated by large amounts of slash covered with

several species of vines, and had a mean slope of 40 percent. Dense clusters of small Redwoods had grown through the slash and reached heights of about two m. Redwood planting was performed in April of 1989, but growth of these trees was slow, and they made little contribution to the community at the time it was studied.

The 1984 Site (Hare Creek '84, Unit D, Age 7): This site was composed of varied microhabitats: marshy areas, dry and open areas, areas covered with ferns, and areas dominated by Redwoods or hardwoods. It consisted of 9 acres with a mean slope of 17 percent. The site was tractor-logged in December of 1987. In March of 1985, foliar herbicide treatment of hardwoord was performed, and Pampas grass was treated with herbicide several years later. The site had been replanted primarily with redwood.

The 1980 Site (Hare Creek '80, Age 11): This 11 acre site had a mean slope of 39 percent. Post-logging treatment did not include burning or use of herbicides. Prior to logging, Douglas-firs (*Pseudotsuga menziesii*) on the site were heavily infested with Black Stain Root Disease. To assist in post-logging control of this problem, seedling Redwoods (a non-host species) were planted; however, the planted trees had not grown to more than one m in height. A few years after logging, Douglas-fir seedlings were planted in clusters around infected stumps, but like the planted Redwoods, these trees did not grow fast enough to reach heights of more than one m. The significant trees and other species in the current community thus are a result of natural revegetation. Common species were Coast Redwood, Douglas-fir, and Tanbark Oak (*Lithocarpus densiflora*) growing to heights of about eight m through a dense cover of shrubs and ferns.

The 1964 Site (Caspar Creek-Unit A, Age 27): This site was 41 acres of forest composed of Coast Redwood and Douglas-fir, with a mean slope of 25 percent. The remains of the last seral stage still existed as a dead understory of Tanbark Oak and Manzanita (*Arctostaphylos columbiana*). The site was in the self-pruning stage that occurs naturally during the regrowth of a forest. Live branches existed on the trees only above a height of about 3 m. Like the Control site, this stand had a nearly complete canopy and few ground-level plants. Its floor had a very thick layer of needles and small dead branches. Shortly after cutting, it was planted with Douglas-fir and possibly Monterey Pine (*Pinus radiata*).

The Control Site (Approximate Age 80): This area consisted of approximately 50 acres of mature Coast Redwood and Douglas-fir, with a minor component of Grand Fir (*Abies grandis*), and was located south of Road 500 at the intersection with County Road 408. Site Caspar East '89, Unit J , lay to the northwest, and site Caspar East '89, Unit K lay to the southeast. The canopy of the Control site was uniformly dense, and the ground layer was covered with dead needles from the trees. The site was clearcut approximately 80 years ago, and had a mean slope of 47 percent.

Trapping

Each site was live-trapped on six widely-spaced dates, three in winter and three in summer. Sixty traps were placed in a randomized pattern as follows: one or two transects were centrally located in an east-west direction through the site, and had a total of 15 locator points placed at 20 m intervals along them. At each of these points, two permanent trapping stations were marked with a stake on either side of the transect(s) at random distances of from 5-15 m. On each trapping date, two traps were set within seven m of this stake in areas deemed most suitable for capturing an animal. Traps were provisioned with toilet tissue (as bedding material), seed, and slices of apple. They were baited with rolled oats. Traps were set beginning three hours before dark, and they were serviced beginning at dawn. Only one site was trapped on a given night.

We used Sonoma Live Traps designed by Dr. Donald E. Isaac of Sonoma State University. Galvanized sheet metal forms a nest box 19 x 9 x 8.5 cm, and this is attached to a removable metal mesh cloth run measuring 25 x 8 x 7.5 cm. A sheet metal door attached to the entrance of the run falls when a treadle located at the entrance to the nest box is depressed, capturing the animal as the it walks from the run into the nest box. A metal wire falls behind the door, securing the animal inside. This design was created to increase the survival rate of captured animals. The completely enclosed nest box provides dry shelter, while the mesh run reduces the amount of condensation created by urine and respiration, and allows the flow of fresh air. Thirty larger traps of this design measuring 25 x 9.5 x 10 cm for the nest box and 30 x 9 x 9 cm for the run were constructed for the study to allow for capture of rat-sized animals. One trap of each size was placed at each trapping station.

Since it is known that small mammals are less active during periods of high moonlight, trapping was limited to the week of the new moon. An attempt was made to trap sites of different ages under equivalent weather conditions. Weather categories were established as follows: (a) no rain in the last 48 h, (b) dry at the time of trap-set, but raining during the trapping period, (c) raining throughout the trap-set and trapping period, (d) snowing at some time during trapping. To achieve the intended equivalence, weather records were kept during each trapping period, and the order of trapping for subsequent periods was chosen to achieve a balance of conditions for the six sites. (As it turned out, all trapping nights were dry except for five in December and one in January, as shown in Table 1. We would have preferred to have weather condition "b" on 19 January rather than 15 January, but rain on 15 January did not commence until the middle of the night, at which time traps had already been set.)

Table 1. Dates and weather conditions of trapping. Weather categories are as follows: a=no rain; b=dry during trap-set but rain overnight; c=rain during trap-set and trapping period; and d=snow at some time during trapping.

SITE											
1989		1987		1984		1980		1964		Control	
Date	Wthr	Date	Wthr	Date	Wthr	Date	Wthr	Date	Wthr	Date	Wthr
20-Dec	d	19-Dec	d	18-Dec	b	17-Dec	a	16-Dec	c	15-Dec	c
14-Jan	a	17-Jan	a	18-Jan	a	19-Jan	a	15-Jan	b	16-Jan	a
12-Feb	a	17-Feb	a	15-Feb	a	13-Jan	a	14-Feb	a	16-Feb	a
11-Jun	a	15-Jun	a	14-Jun	a	10-Jun	a	13-Jun	a	12-Jun	a
11-Jul	a	13-Jul	a	14-Jul	a	9-Jul	a	12-Jul	a	10-Jul	a
9-Aug	a	7-Aug	a	6-Aug	a	11-Aug	a	8-Aug	a	10-Aug	a

Data on Captured Animals

Captured animals were removed from the traps into a cloth bag and then weighed with one of two Pesola spring scales (300 g or 500 g capacity). Animals were held through the cloth bag by the nape of the neck. The bag was inverted to reveal the animal, but the bag was left over the eyes of highly active individuals to minimize fright. Measurements were taken by standard methods (Jameson and Peeters 1988) of ear length, hind foot length, tail length, and body length. Total length was obtained by adding tail length and body length. These data appear in Appendix C. Sex and reproductive status were determined. Animals were examined for ectoparasites, abnormalities, and injuries, marked with a permanent marker on the underside of the tail for tallying recaptures, and then released.

Data on Plant Communities

A separate study of changes in the plant communities of these and other clearcut sites on the JDSF is being conducted by Dina Rivas under the direction of Dr. Chris K. Kjeldsen of Sonoma State University. These investigators have kindly allowed us to utilize their data on the six study areas for an analysis of various factors that may be associated with the small mammal communities. Details of their sampling techniques need not be given here, but a short summary is appropriate. At each trapping station, a single circular plot of 7 m radius was established. In each quadrant of the circle, visual estimates were made of the cover of each plant species, as well as bare ground, slash (diameters of 2-9.9 cm, small; 11-19.9 cm, medium; and >20 cm, large), and the tops of stumps. Depth of slash and the slope of the station were also measured. We combined cover on plant data into the following categories: ferns, herbs, grasses, shrubs (heights of 0-.99 m and 1-4.99 m), wetland species, broadleaved trees (heights of 0-.99 m, 1-4.99 m, and >5 m), coniferous trees (heights of 0-.99 m, 1-4.99 m, and >5 m). (Some of the category names have been simplified below, for example "shrubs 1-5.") The total number of plant species and the total cover were calculated for each station.

RESULTS

Relative Abundance of Animal Species on Sites of Different Ages

The data obtained in this study do not provide estimates of density, but rather of comparative relative abundance. For most analyses, recaptures were not considered; each of the six single-night samples was regarded as an independent estimate. The percentage of trapping success ranged from 17 percent on the Control site, where the smallest number of captures was obtained, to 37 percent on the 1980 site, where the largest number of captures was recorded.

During the study, individuals were captured representing ten species, all but one of which (the Pacific Jumping Mouse, *Zapus trinotatus*) showed a trend in the ages of the sites it occupied. Figs. 1 and 2 show these trends, and complete numerical data appear in Table 4 on page 16. Four species, the Sonoma Chipmunk (*Tamias sonomae*), White-footed Deer Mouse (*Peromyscus maniculatus*), Dusky-footed Woodrat (*Neotoma fuscipes*), and California Red-backed Vole

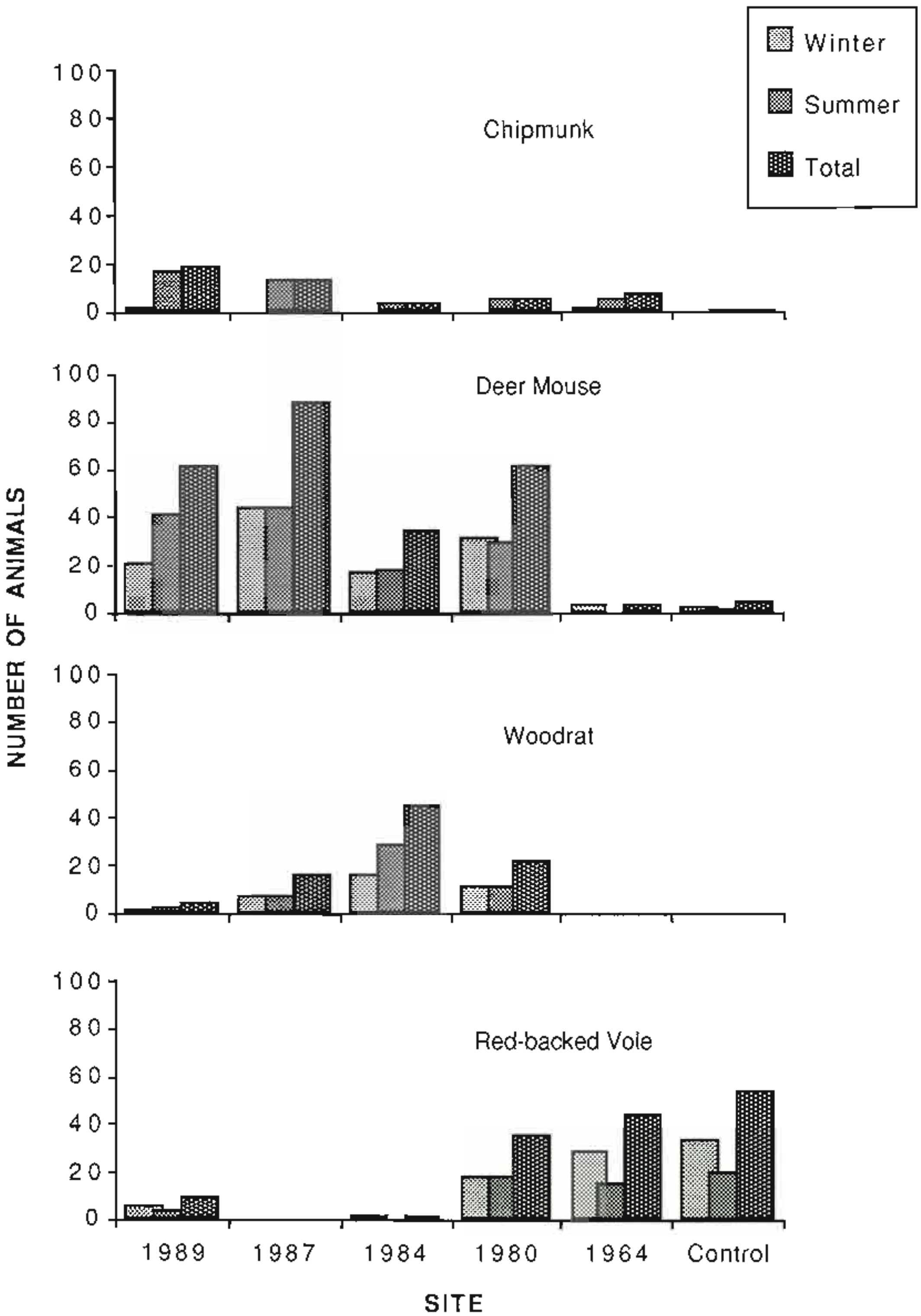

Figure 1. Seasonal and total captures of the four most common species in the six study areas.

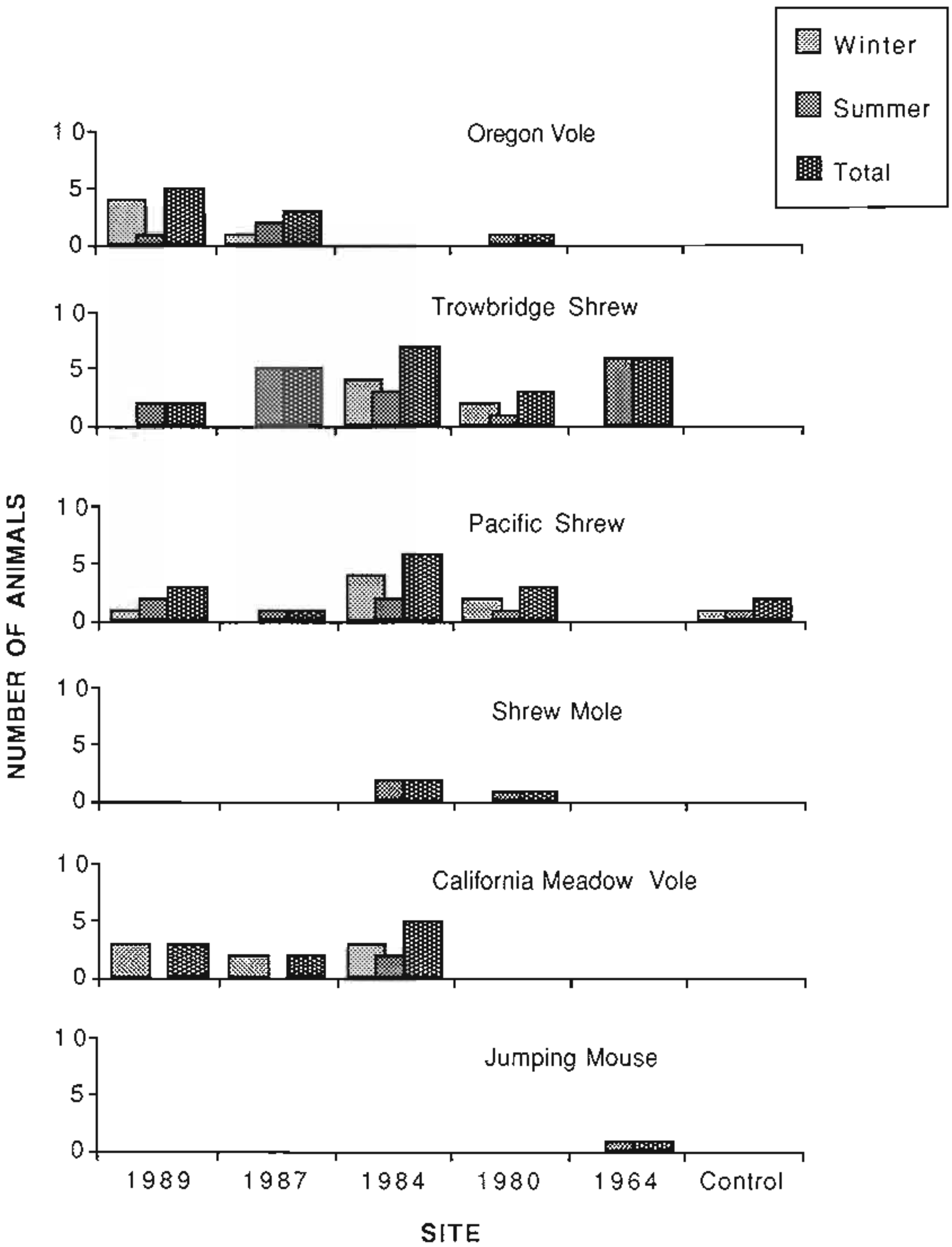

Figure 2. Seasonal and total captures of the six least abundant species in the six study areas. (Note that the y-axis scale of this figure has been expanded in comparison with that of Fig. 1.)

(*Clethrionomys californicus*), were much more frequently captured than the others, and had peak abundance levels in successively older stands. Chi-square tests of observed numbers on each site compared with values that would be expected if the animals were equally distributed in the sites proved significant at the .01 level for all of these species, indicating that each species was found significantly more often in some sites than in others. Of the five remaining species, the Oregon Vole (*Microtus oregoni*) invaded the earliest sites in a pattern resembling that of the Chipmunk. The California Meadow Vole (*Microtus californicus*) was found in early to mid-aged stands. Trowbridge Shrew (*Sorex trowbridgii*), Pacific Shrew (*S. pacificus*), and Shrew Mole (*Neurotrichus gibbsii*), were most abundant in stands of intermediate ages. Capture numbers were too small for these species, however, to allow use of the Chi-square test.

Viewing the capture data on sites of different ages by numbers gives the following general picture (Fig. 3). Numerically, the Deer Mouse was strongly dominant on the 1989 and 1987 sites, while the Red-backed Vole was similarly dominant on the 1964 and Control sites. On the 1980 site, these two species were codominant. Only on the 1984 site was a third species, the Woodrat, relatively more abundant than either of these two species. Total capture values were about twice as high on the four youngest sites, which were generally open and dominated by various plant types (discussed below), than on the two oldest sites, where conifers of different ages provided a nearly complete tree canopy.

Total live-weight biomass for the six sites differed strikingly (Fig. 3). The largest value, which occurred on the 1984 site, was 6.6 times as high as for the Control site, and all of the four youngest sites had values at least 2.3 times as high as for either of the two oldest sites.

Viewed in terms of biomass, the relative dominance of the species is quite different from the picture just presented for numerical capture values. By this criterion, the Woodrat strongly dominated the 1987, 1984, and 1980 sites. The Chipmunk also assumed a more important role, becoming an important element in both the 1989 and 1964 sites. The Red-backed Vole remained nearly as dominant on both sites with a closed coniferous canopy (1964 and the Control) in terms of biomass as it was in numbers.

Some caution is needed in interpreting either the numerical or biomass value as a definitive measure of the importance of a species in a given stand. First, data taken on the number of traps that were visited by animals but not sprung (judged by eaten bait or fresh scat) indicated that the trapped numbers represented only a portion of the total population. For the six sites, the number of such evidences ranged from 46 to 87 percent of the capture value.

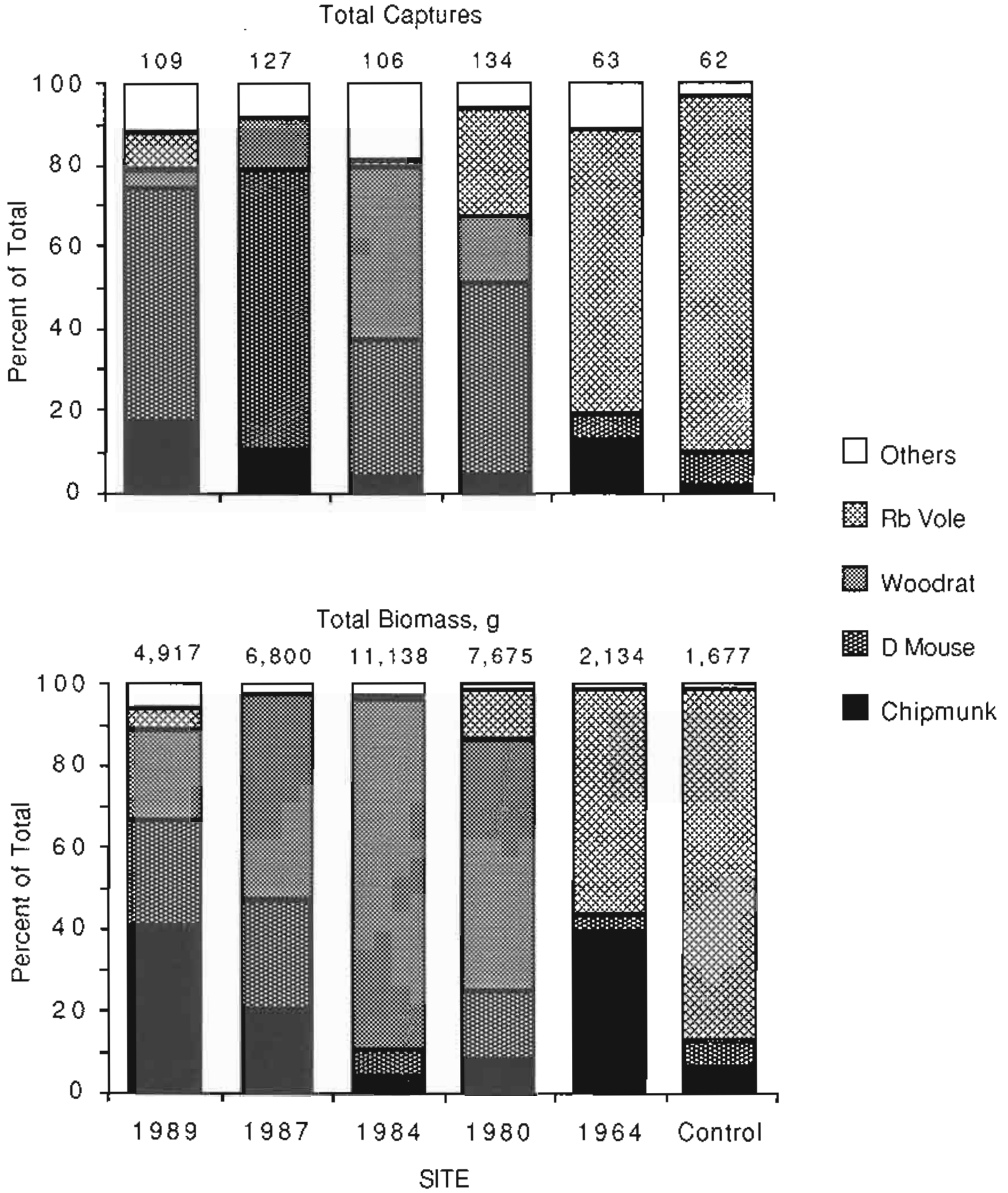

Figure 3. Percentage composition of small mammal assemblages on each of six sites, viewed numerically (above) and by live-weight biomass (below). The value above each bar represents the total for all species at that site.

More importantly, the different species probably have different rates of biomass production and population turnover, thus the standing crop value at any one time, by either a numerical or biomass measure, does not represent annual production. Data obtained on recaptured animals, which appear below in Table 2, suggest that the Woodrats may have had less turnover of individuals in the population than other species. In different trapping periods, Woodrats were recaptured at rates from 17 to 55 percent, more than twice as frequently as the Deer Mouse or Red-backed Vole. Only one Chipmunk was recaptured during the entire study. Greater fidelity of the Woodrats for areas where the traps were set is another possible reason for their higher recapture rates.

Table 2. Data on recapture of animals from trapping period to trapping period in all sites. Values represent those animals recaptured in a given period, irrespective of when they were marked. Most individuals were marked in the previous period; a few were recaptured twice.

	Species			
Month	**RB Vole**	**D Mouse**	**Woodrat**	**Chipmunk**
January				
Total Captures	43	43	12	2
Recaptures	0	0	2	0
Percent	*0*	*0*	*17*	*0*
February				
Total Captures	35	50	16	0
Recaptures	1	6	6	0
Percent	*3*	*12*	*38*	*0*
June				
Total Captures	21	39	9	14
Recaptures	0	0	2	1
Percent	*0*	*0*	*22*	*7*
July				
Total Captures	23	44	20	12
Recaptures	1	8	7	0
Percent	*5*	*18*	*35*	*0*
August				
Total Captures	17	54	22	21
Recaptures	2	6	12	0
Percent	*12*	*11*	*55*	*0*

Plant Species Composition and Other Site Factors

All of the data on plants were obtained during the winter, hence some species were not sampled. The general characteristics of the sites were nevertheless well represented. Forty-four species were abundant enough to be included individually in the cover estimates, and all of these are shown in Appendix B. To clarify the major successional trends, we have shown data for the most important of these in Table 3.

The 1989 site (two years since logging) had a low value for total plant cover of 17.2 percent. The most abundant species were Sword Fern (*Polystichum munitum*) and Coastal Redwood in the 1-5 m category. Three herbs were moderately abundant on this site and absent or nearly so on others: Thistle (*Cirsium sp.*), one species of Bedstraw (*Galium aparine*), and Hedge Nettle (*Stachys rigida*). Redwood Violet (*Viola sempervirens*) was present on this and all other sites at moderate levels. Two herbs were established on this site but become considerably more abundant on mid-aged sites. These were Douglas Iris (*Iris douglasiana*) and Yerba de Selva (*Whipplea modesta*), which became strongly dominant at the ground level of the 1984 and 1980 sites. One small shrub, White-stemmed Raspberry (*Rubus leucodermis*) was present, but became more abundant on the 1987 site as did one broadleaved tree, Tanbark Oak. One plant on this site was very abundant during the summer, but was not represented in the winter data: Italian Ryegrass (*Lolium multiflorum*). This was the only plant on any site with such a conspicuous seasonal difference, although many of the vines added considerable growth during the summer.

The main pattern on the four-year-old 1987 site was continued growth of species present at lower cover values in the two-year-old site. Total plant cover was 31 percent. *Galium aparine* and *Cirsium sp.* became insignificant, but another species characteristic of early succession (Australian Fireweed, *Erectites prenanthoides*) was first observed on this site and important on no other. Additional shrubs were found on this site, notably Manzanita, Rhododendron (*Rhododendron macrophyllum*), and Thimbleberry (*Rubus parviflorus*). Douglas-fir was first noted as small seedlings on this site.

On the 1984 site, which represented seven years since logging, the total plant cover was 88.9 percent, three times as great as for the 1987 site. Several factors were responsible for this difference. First was the continued growth of shrubs and trees; second, the presence of a large population of Ceanothus (*Ceanothus thrysifloris*) not found on other sites; third, the marked

Table 3. Cover values for the most abundant plants of the study sites. Values for trees >5 m were calculated by apportioning a total canopy cover value estimated visually on the sites according to the total cross-sectional trunk area values for the species of each site. (continued next page)

	SITE					
Herbs	1989	1987	1984	1980	1964	Control
Cirsium sp.	0.54	0.08	0.02	0.02		
Erechtites prenanthoides		0.48	0.09			
Fragaria sp.			0.34			
Galium aparine	0.33					
Galium spp.		0.13	0.06	0.03	0.01	
Iris douglasiana	0.28	0.93	1.39	0.89		
Oxalis oregana	0.19	0.01	0.03	0.18	0.11	4.72
Stachys rigida	0.59	0.03				
Viola sempervirens	1.12	0.21	1.35	1.96	0.18	0.11
Whipplea modesta	0.70	3.03	24.82	30.90	0.02	
Grasses						
Hierochloe occidentalis	0.03	0.28	1.08	4.03	0.45	0.40
Holcus lanatus			0.57	0.03		
Ferns						
Polystichum munitum	3.77	6.42	2.30	3.77	4.88	17.59
Wetland species						
Carex brevicaulis	0.22		0.19			
Cyperus sp.			0.33			
Juncus sp.			8.72	0.03		
Shrubs 0 to 1 m						
Arctostaphylos columbiana		0.13	1.18	0.50		
Ceanothus thrysifloris			0.71	0.38		
Gaultheria shallon			0.42	1.34		0.13
Lonicera sp.	0.04	0.04	0.19	0.73	0.01	0.02
Rhododendron macrophyllum		0.11		0.38	0.56	
Rubus leucodermis	0.99	2.76	0.18	0.06		
Rubus parviflorus		0.19	0.19	0.08		
Rubus sp.			0.08	0.11	0.61	
Rubus ursinus	0.04	1.03	0.61	1.13		
Vaccinium ovatum	0.28	0.75	0.19	1.39	0.69	1.08
Shrubs 1 to 5 m						
Arctostaphylos columbiana			1.72	7.88		
Ceanothus thrysifloris			11.42	3.88		
Rhododendron macrophyllum				1.19		

increase in the cover of Yerba de Selva; and finally a continuous, dense cover of wetland species on some portions of the site. Associated with these wetland plants (*Carex and Juncus*) were locally abundant populations of wild strawberry (*Fragaria sp.*) and Velvet Grass (*Holcus lanatus*). The 1980 site (age 11 years) had a very similar complex of species but a higher cover value of 112.6 percent. It lacked wetland species, and had a greater cover value for Vanilla Grass (*Hierochloe occidentalis*), which was the most common grass on all sites.

Table 3. (continued)

	SITE					
Broadleaved trees 0 to 1 m	**1989**	**1987**	**1984**	**1980**	**1964**	**Control**
Lithocarpus densiflora	0.23	1.83	0.20	0.82	2.72	0.64
Myrica californica			0.06	0.03		
Broadleaved trees 1 to 5 m						
Lithocarpus densiflora		0.67	5.46	16.08		0.63
Myrica californica			0.08	1.42		
Broadleaved trees >5 m						
Lithocarpus densiflora				0.33	1.99	
Conifers 0 to 1 m						
Abies grandis				0.10		
Pseudotsuga menziesii		0.14	1.50	0.94	0.05	
Sequoia sempervirens	0.58	0.84	0.86	0.84	0.23	0.76
Tsuga heterophylla			0.38		0.13	
Conifers 1 to 5 m						
Abies grandis				1.02		
Pseudotsuga menziesii			0.68	9.23		
Sequoia sempervirens	3.55	7.95	21.37	15.16	0.04	1.68
Tsuga heterophylla					0.25	
Conifers >5 m						
Abies grandis					0.58	
Pseudotsuga menziesii			0.27		17.95	37.75
Sequoia sempervirens				6.96	66.04	50.70
Tsuga heterophylla					1.10	4.93

The 1964 site (age 27 years) was markedly different from any of the previous sites. The abundant shrub cover of the 1984 and 1980 sites did not exist, presumably because tree crowns had grown into a nearly complete canopy and shaded them out. These trees were almost exclusively conifers, with Redwood constituting 75 percent and Douglas-fir 20 percent of the total tree cover of 87.7 percent. The understory of this site was very sparse due to a thick mat of small limbs and needles created by the self-pruning of the trees as well as to the dense shade created by the canopy. By contrast, the Control site (age 80 years) had a very open, shaded understory in which Sword Fern reached a cover value three times greater than for younger stands, and Redwood Sorrel (*Oxalis oregana*) became abundant. The number of shrub species and shrub cover values were low.

For analysis of their affect on small mammal populations, plant data were pooled into the categories shown in Table 4. Abiotic factors, principally various measures of dead wood, are also presented in this table.

Table 4. Summary of site factors and their mean values in each site. All site characteristic and plant units are in percent cover except for "site age" (years), "slope" (percent), "slash depth" (cm) and"number of plant species per station" (an average of numerical talleys). For animal trapping data, "evidence" is a talley of traps judged to have been visited by animals but not sprung, and numbers listed for each species are total captures. (continued next page)

	SITE					
SITE CHARACTERISTICS	1989	1987	1984	1980	1964	Control
Site Age	2	4	7	11	27	80
Slope	33.1	40.0	16.7	38.8	24.6	46.9
Bare Ground	8.8	2.6	10.0	4.3	2.2	0.9
Stump	7.2	5.1	3.5	4.2	4.0	0.5
Small Slash	40.9	32.0	11.7	8.4	22.0	7.2
Small Slash Depth	23.7	22.6	9.5	9.1	34.1	6.2
Medium Slash	31.5	30.1	18.3	7.4	7.7	3.5
Medium Slash Depth	35.2	28.5	21.9	12.7	12.0	7.8
Large Slash	10.5	11.6	3.4	2.1	5.7	5.9
Large Slash Depth	19.7	19.2	12.3	13.8	14.4	19.6
Total Slash	81.0	75.0	33.4	17.9	35.3	16.5
PLANT DATA						
No. Species/Station	4.1	5.6	8.4	9.8	3.4	3.4
Ferns	3.4	6.4	2.5	3.8	4.9	17.6
Herbs	3.5	5.1	29.1	34.6	0.3	4.9
Grasses	0.1	2.4	2.2	4.2	0.7	0.4
Wetland Species	0.3	0.0	9.2	0.0	0.0	0.0
Shrubs 0 to 1 m	2.0	5.5	3.9	6.1	1.3	1.2
Shrubs 1 to 5 m	0.0	0.0	13.1	11.6	0.0	0.0
Broadlv. Trees 0 to 1 m	0.0	0.7	5.5	18.3	0.0	0.6
Broadlv. Trees 1 to 5 m	0.3	1.8	0.3	0.9	2.7	0.6
Broadlv. Trees >5 m	0.0	0.0	0.0	0.7	0.0	0.0
Conifers 0 to 1 m	4.1	8.0	21.4	25.4	0.3	1.7
Conifers 1 to 5 m	0.6	1.0	2.7	1.8	0.3	1.1
Conifers >5 m	0.0	0.0	0.3	4.9	89.3	93.5
Total Cover	17.2	31.0	88.9	112.6	99.8	121.5

Table 4. Summary of site factors (continued)

	SITE					
WINTER TRAPPING DATA	1989	1987	1984	1980	1964	Control
Evidence	37	34	55	44	15	29
Total Species	7	4	7	5	3	3
Red-backed Vole	6	0	2	18	29	34
Deer Mouse	21	44	17	32	4	3
Woodrat	2	8	16	11	0	0
Pacific Shrew	1	0	4	2	0	1
Trowbridge Shrew	0	0	4	2	0	0
Shrew Mole	0	0	0	0	0	0
Oregon Vole	4	1	0	0	0	0
Jumping Mouse	0	0	0	0	0	0
Chipmunk	2	0	0	0	2	0
Meadow Vole	3	2	3	0	0	0
SUMMER TRAPPING DATA						
Evidence	28	25	25	35	30	25
Total Species	7	6	7	8	4	4
Red-backed Vole	4	0	0	18	15	20
Deer Mouse	41	44	18	30	0	2
Woodrat	3	8	29	11	0	0
Pacific Shrew	2	1	2	1	0	1
Trowbridge Shrew	2	5	3	1	6	0
Shrew Mole	0	0	2	1	0	0
Oregon Vole	1	2	0	1	0	0
Jumping Mouse	0	0	0	0	1	0
Chipmunk	17	13	4	6	6	1
Meadow Vole	0	0	2	0	0	0

Association of Site Factors with Small Mammal Populations

The purpose of this aspect of the study was to discover the major habitat associations of the species. Some of the variables were not used in this attempt. As described in Methods, all of the sites were chosen to be similar in terms of slope and aspect: therefore, these factors were not used analytically. Site age was the obvious and overriding factor with which many of the variables were associated, and was therefore not used as a variable on its own. Instead, our purpose was to analyze how the physical and biological conditions of the sites changed with time, and how these changes were associated with the time-trends of the small mammals.

Site Factors Used in Statistical Analysis. All of the site factors are shown in Table 4, along with their mean values. Each of these was examined for its usefulness in this aspect of the study, and most were retained. One of the variables had so few non-zero values as to be of little use (Broadleaved trees > 5 m). Total slash was better represented by some of its component slash values, and was also not used. The slash variables were reduced to three: small slash volume, the product of small slash cover and small slash depth, medium slash volume, similarly calculated, and large slash depth. This last variable was chosen over either large slash cover or large slash volume because it was a better representation of the overall presence of large logs on the sites.

All of the variables were analyzed for normality, and most were decidedly non-normal. Attempts were made to transform these variables to normality using a variety of formulae, but this attempt was not successful. Some transformed well with logarithms, square roots, or inverses, but key variables were non-transformable in all cases. Lack of normality meant that non-parametric statistics were needed, and precluded use of the two most commonly used multivariate methods: multiple regression and discriminant analysis. We selected Spearman's Coefficient of Rank Correlation (Steele and Torrie, 1960) to identify and test the significance of correlations among pairs of factors, and then developed a means (presented below) of showing how correlations for the mammals were associated with a ranking of site factors according to successional trends.

Successional Trends in the Site Factors. In a series of factors undergoing change with time, some would be expected to peak early in the time sequence, others in the middle, and still others near the end. As shown in Figures 4-7, such was the case with the variables employed in this analysis. Indeed, at least one factor had its mode in each of the six site ages. These figures also help clarify properties of the individual factors.

For example, in Fig. 4, it can be noted that four of the variables each had a strong mode in 1989 (medium slash volume, Chipmunk, Oregon Vole, and stump), while two others were distinctly bimodal. The first of these, small slash volume, had a secondary peak in 1964 due to the self-pruning of small conifers referred to above. Large slash depth did not show a strong time trend, but the peaks in 1989 and the Control site do correspond with the field observation that the early sites had a number of large logs in piled slash, and the Control site had some large fallen trees. In general, Fig. 4 shows the prevalence of logging slash in the youngest site.

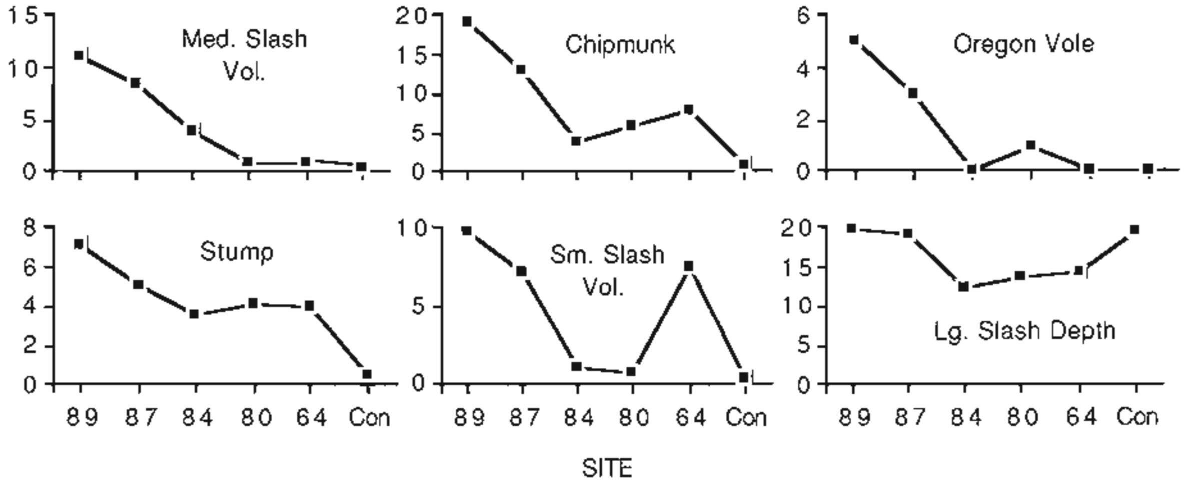

Figure 4. Site factors used in statistical analysis that had modal values in the 1989 site (age 2). (See Table 4 for units.)

Figure 5 shows that only one factor (Deer Mouse) peaked in the 1987 site (age 4), but eight had modes in the 1984 site (age 7). Note that three of the figures for animal species (Meadow Vole and the two shrews) are based on small numbers of captures. Taken together, the factors shown in this figure demonstrate a larger number of animal species peaking in sites of these ages than in the 1989 site, and the growth of small woody plants. (Recall from the discussion of plant species above that only the 1984 site had a marshy area harboring wetland plants.)

In Fig. 6, one can observe that only characteristics of the plant community peaked in the 1980 site. Not only was the number of plant species highest, but the community was characterized by a dense ground cover of herbs, grasses, and small woody plants classified as shrubs. A number of these shrubs characterize more mesic sites and are found in the openings of old-growth coniferous stands: Honeysuckle, California Blackberry, Rhododendron, Salal, and California Huckleberry (see Table 3). Rapidly growing Redwood, Douglas-fir and Tanbark Oak were also prevalent on the 1980 site.

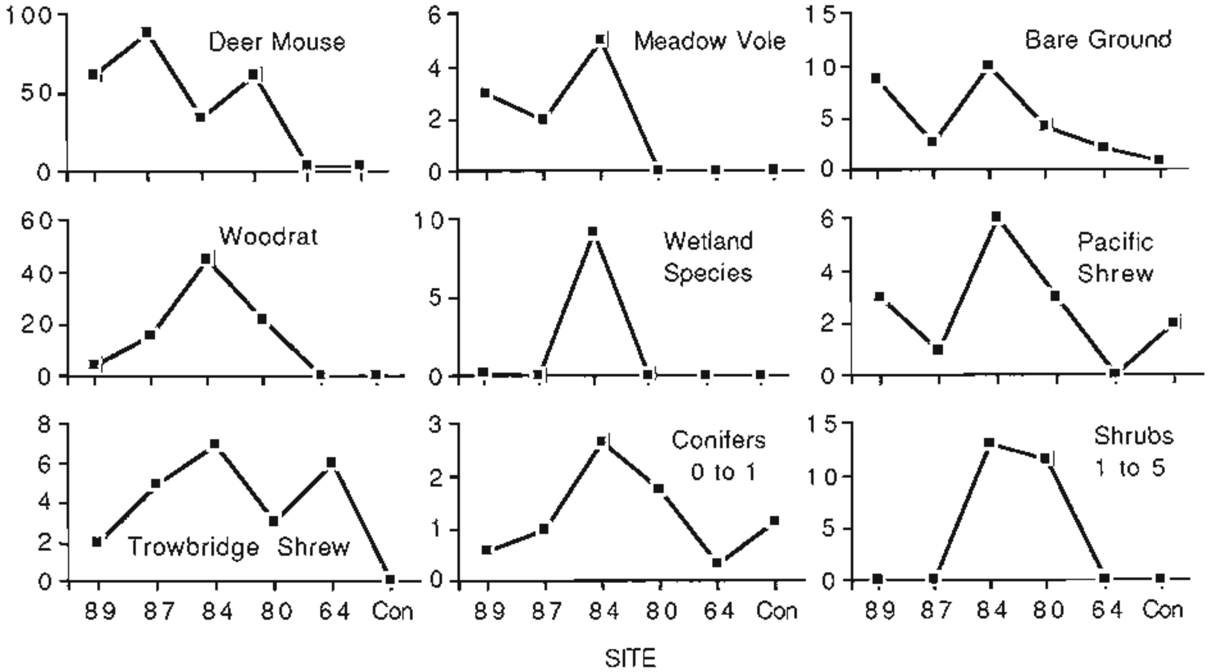

Figure 5. Site factors used in statistical analysis that had modal values in the 1987 site (age 4, Deer Mouse only) and 1984 site (age 7). (See Table 4 for units.)

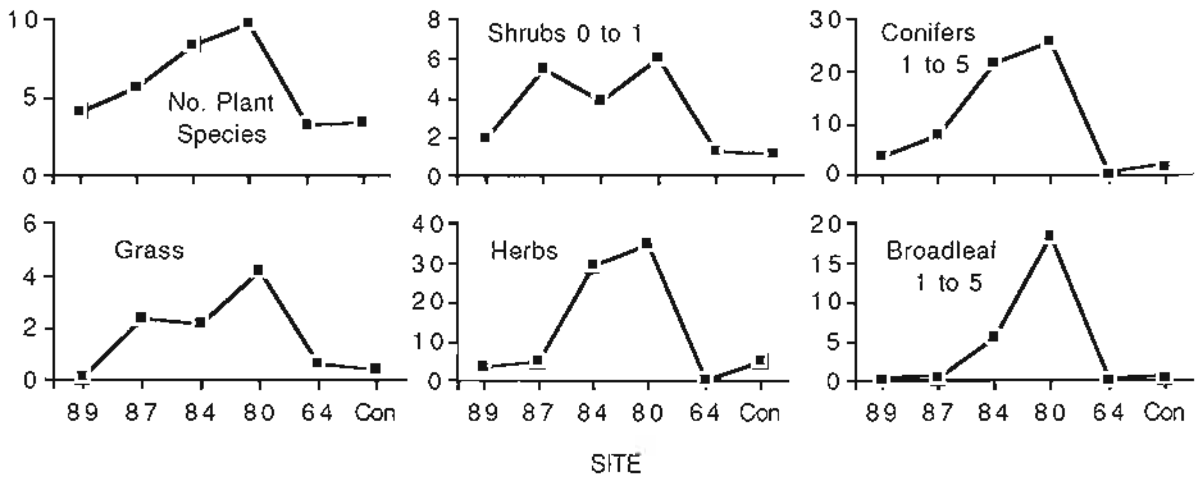

Figure 6. Site factors used in statistical analysis that had modal values in the 1980 site (age 11). (See Table 4 for units.)

The single factor that peaked in the 1964 site was the seedlings of broadleaved trees (Fig. 7). Field observations indicated that this was due to a large number of Tanbark Oak seedlings growing poorly in the deep shade of the conifers. Vegetative factors that had highest values in the oldest site characterize a simple community in which large conifers dominate a nearly closed canopy and Sword Fern creates a scattered ground cover.

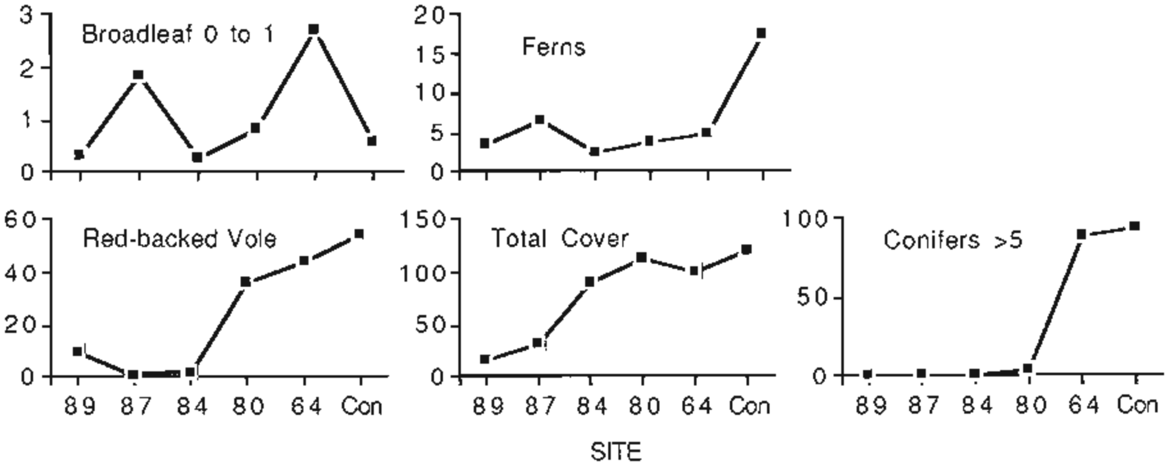

Figure 7. Site factors used in statistical analysis that had modal values in the 1964 site (age 27) or Control site (approximate age 80). (See Table 4 for units.)

Statistical Analysis of the Association of Small Mammals with Site Factors. The distinct differences in the time trends of most of the factors presented in Figs. 4-7 suggested that they could be placed in a sequence associated with ages of the sites. We did this using two criteria: the modal year for the factor and its correlation with site age using the Spearman's Coefficient of Rank Correlation, which requires no assumptions regarding the distributions of the variates. Capture values for a given species at each of the 180 individual stations of the six sites were small integers not suitable for statistical analysis, particularly for the less common species. We wished to include some of the variation within sites, however, and therefore pooled the data for each one-third of the six sites, which created 18 samples representing ten stations each (20 traps for six trapping periods for each subsample).

Table 5 shows the site factors arranged in sequence, with those characterizing the two-year-old stand (1989) at the top and those characterizing the oldest site (control) at the bottom. Note that five of the six factors with a modal year of two show significant negative correlation with site age, as does the single factor for year four. Only two of the year seven factors are so correlated, and none for years 11 and 27. Three of the four factors with a modal year of 80 are

Table 5. Correlation of animal species with site characteristics along a successional sequence. Habitat factors were first placed in the order of modal year. Within each modal year, factors were sequenced by their correlation with site age using Spearman's Coefficient. In this sequence, negative values indicate association with early site ages; positive values show association with advancing site ages. For the animal species, values represent correlations with the site factors arranged on the left by this successional sequence. All coefficients having absolute values of .47 or greater are significant at the .05 level, those of .59 or greater at the .01 level, and those at or above .71 at the .001 level. These are all shown in bold type for the animal species. We have also shown coefficients from .40 to .46, which have probabilities <.10 but >.05, because they help show overall trends. For each coefficient, n (the number of pairs) was 18.

	SEQUENCE		SPECIES							
VARIABLE	Spear. Coeff.	Modal Year	Chip-munk	Ore. Vole	Deer Mouse	Mead. Vole	Wood-rat	Pacif. Shrew	Trow. Shrew	Red Vole
Med. Slash Vol.	-0.91	2	**0.55**	**0.64**	**0.67**	**0.60**				**-0.73**
Chipmunk	-0.65	2		**0.61**						-0.44
Oregon Vole	-0.64	2	**0.61**		**0.74**	0.41				**-0.48**
Stump	-0.64	2	**0.51**		0.40					-0.44
Sm. Slash Vol.	-0.53	2	**0.65**							
Lg. Slash Depth	-0.08	2								
Deer Mouse	-0.75	4		**0.74**		0.42	0.46			**-0.67**
Meadow Vole	-0.58	7	0.41		0.42					**-0.61**
Bare Ground	-0.50	7				**0.55**	**0.60**			
Woodrat	-0.35	7			0.46			**0.52**	**0.62**	**-0.49**
Wetland Species	-0.39	7				**0.57**				
Pacific Shrew	-0.21	7					**0.52**			
Trowbridge Shrew	-0.19	7					**0.62**			
Conifers 0-1 m	-0.06	7					**0.69**			
Shrubs 1-5 m	-0.01	7			**0.52**		**0.79**	**0.58**	0.40	
No. Plant Species	-0.35	11					**0.81**			
Shrubs 0-1 m	-0.29	11					**0.60**			
Conifers 1-5 m	-0.29	11					**0.82**	0.46	**0.53**	
Grass	-0.17	11								
Herb	-0.07	11					**0.81**	**0.58**		
Broadleaf 1-5 m	0.12	11						**0.55**		
Broadleaf 0-1 m	0.13	27	-0.44				**0.57**			
Fern	0.42	80								
Red-backed Vole	0.81	80	-0.44	**-0.48**	**-0.67**	**-0.61**	**-0.49**			
Total Cover	0.88	80	**-0.67**		**-0.53**					**0.66**
Conifer >5 m	0.93	80	**-0.59**	**-0.61**	**-0.73**	**-0.53**	**-0.51**			**0.78**

positively correlated with site age. For the factors of middle years, the insignificant Spearman's coefficients might be interpreted as showing that there is no time pattern, but the graphs presented in the previous section show that most of these factors had distinct trends that were not linear with respect to time.

The small mammals can be placed within the time trend by noting the factors of the successional sequence with which they had significant correlations (Table 5). The eight species with sufficient captures for analysis fall into three groups, those that were exclusively or primarily associated with factors of the early sites (Chipmunk, Oregon Vole, Deer Mouse, and Meadow Vole), those associated with factors of the mid-aged sites (Woodrat, Pacific Shrew, and Trowbridge Shrew), and one species associated with factors characterizing older stands (the Red-backed Vole).

The four species with early-age associations were similar in all being correlated positively with medium slash volume and negatively correlated with two or three of the late-age site factors. They also showed several differences. Chipmunks were more strongly correlated with the woody factors of the early sites than the other three (correlation with stump and small slash volume in addition to medium slash volume). The Oregon Vole, one of the less common species, was associated only with the early site factors, but with fewer than the Chipmunk. The Deer Mouse was correlated with a few factors of intermediate site-age indicating its occupancy of a broader range of conditions than the Chipmunk or Oregon Vole. It was the most frequently captured species of the study, comprising 43% of the total sample, and was very abundant on sites of the first four ages. It was also present at much lower levels in the 1964 and Control sites. The Meadow Vole represents a special case. It was captured predominantly in areas where wetland species were found, and correlated with these species. As mentioned above, the abundance of these plant types on the 1984 site and not others is due to the hydrological conditions on this site, not its age. Our data are therefore not sufficient to indicate any real successional trend for the Meadow Vole, although the presence of a continuous tree canopy would create shade that excludes the cover of low-growing vegetation that this species prefers.

Woodrat correlated significantly with most of the factors characteristic of mid-aged sites (ages 7 and 11 years). Other than the animal species themselves, these factors were those that represent development of increasingly dense vegetative cover. Pacific and Trowbridge

Shrews showed a similar trend, but with fewer significant correlations. It should be noted that the combined capture numbers for these shrews were less than a third of the Woodrat values for the mid-aged sites.

The Red-backed Vole correlated significantly with two of the three factors having modal years in the Control site, and was the only species having negative correlations with factors of the early and middle site ages.

Correlations Among Site Factors

Investigation of the pair-wise Spearman's Coefficients for site factors revealed that those representing the physical and vegetative characteristics of the sites also clustered into three groups. The first of these were three measures of downed wood: small slash volume, medium slash volume and stump. The last two of these both correlated with the first (Table 6). None of these three factors correlated significantly with any of the other non-animal variables.

Table 6. Significant Spearman's correlations among early site factors (.05 level or above, see legend Table 5) .

	Small Slash Vol.
Sm. Slash Vol.	1.00
Med. Slash Vol.	0.50
Stump	0.66

The second group consisted of nine factors characteristic of mid-aged sites. As shown in Table 7, all but one of these (bare ground) were characteristics of the plant community. Only one of these factors showed a significant correlation outside of this group: Broadleaf 1-5 m with Total Cover (0.49). These factors thus represent a tightly nested set of intercorrelated factors.

The final distinct set of non-animal site factors consisted of the two major characteristics of the 1964 and Control sites: Conifers >5 m and Total Cover, which had a correlation coefficient of 0.80. The only significant correlation outside this set was between Broadleaf 1-5 and Total Cover just mentioned above.

Table 7. Significant Spearman's correlations among mid-age site factors (.05 level or above, see legend Table 5) .

	S0to1	S1to5	B1to5	C0to1	NoSp	C1to5	Grass	Herb	BrGr
Shrubs 0-1 m	1.00								
Shrubs 1-5 m	0.58	1.00							
Broadleaf 1-5 m	0.61	0.65	1.00						
Conifers 0-1 m	0.61	0.68	0.55	1.00					
No. Plant Species	0.83	0.78	0.72	0.72	1.00				
Conifers 1-5 m	0.50	0.77	0.64	0.66	0.77	1.00			
Grass	0.78	0.60	0.60	0.57	0.72	0.67	1.00		
Herb	0.57	0.83	0.82	0.70	0.79	0.76	0.60	1.00	
Bare Ground		0.56		0.59	0.60	0.61			1.00

The distinctness of these three sets of factors may be due in part to the ages of the sites selected for the study. If ages between four and seven and between 11 and 27 had been represented, then more of a continuum might have been observed.

The animal species associations discussed in the previous section can also be understood in the context of these three sets of site factors. The Chipmunk and Oregon Vole had significant correlations only with the first set. The Deer Mouse and Meadow Vole had a significant correlation with one factor in each of the first two sets. The Woodrat, Pacific Shrew and Trowbridge Shrew had correlations only with factors in the second set. Finally, the Red-backed Vole correlated with both of the factors in the third set.

Diversity of Small Mammals in the Sites

Since the data were taken in an identical manner in each of the six sites, the total capture values represent a valid data set for comparing species diversity. In species richness, the 1989, 1984, and 1980 sites ranked highest with eight species each, which was twice the value for the Control site (Table 8). To examine the contribution of "evenness" or "equitability" to diversity, we calculated the Simpson and Shannon Indices of species diversity (Brower *et al.* 1990), both of which combine richness and equitability into a single value in which diversity is measured from a low of zero to a high of one. By both of these measures, the 1984 site was approximately three times as diverse as the Control site, and the 1989 and 1980 sites were similarly high in small mammal diversity. The 1987 and 1964 sites had intermediate diversity values.

Table 8. Diversity of small mammals in the six study sites as measured by species richness (Total Species) and indices that combine species richness and equitability (Simpson and Shannon Indices). Numbers for the species represent total captures.

Site	1989	1987	1984	1980	1964	Control	
Site Age	2	4	7	11	27	80	Total
Deer Mouse	62	88	35	62	4	5	256
Red-backed Vole	10	0	2	36	44	54	146
Woodrat	5	16	45	22	0	0	88
Chipmunk	19	13	4	6	8	1	51
Trowbridge Shrew	2	5	7	3	6	0	23
Pacific Shrew	3	1	6	3	0	2	15
Meadow Vole	3	2	5	0	0	0	10
Oregon Vole	5	3	0	1	0	0	9
Shrew Mole	0	0	2	1	0	0	3
Jumping Mouse	0	0	0	0	1	0	1
Total Animals	109	128	106	134	63	62	602
Total Species	8	7	8	8	5	4	
Simpson Index	0.64	0.50	0.71	0.69	0.49	0.24	
Shannon Index	0.61	0.46	0.65	0.60	0.42	0.22	

DISCUSSION

Species Presences and Abundances

Many authors have noted time changes in the populations of small mammals of logged areas. We will discuss individual species and then the overall pattern. Van Horne (1982) found that Deer Mouse populations (*Peromyscus maniculatus*) were 2-3 times higher in 23 year old stands of spruce-hemlock forest in Alaska than in stands of ages 2, 7, or 190 years. Tevis (1956) observed populations of this species to be 3-4 times higher in 4-10 year old stands of Douglas-fir forest in Humboldt and Trinity Counties, California, than in virgin forest. In clearcut, burned larch-fir forests of western Montana studied by Halvorson (1982), *P. maniculatus* reached peak abundances two years after a cool burn. Sullivan (1978), studying Deer Mouse irruptions in second-growth Western Hemlock-Western Red Cedar-Douglas-fir forests of British Columbia, concluded that the high populations were due primarily to juveniles recruited in late summer, and that winter populations of the species were equivalent in forested and logged areas. Our data show notably higher Deer Mouse populations in both winter and summer in young-age stands compared with those dominated by taller conifers, and correspond closely with those of Tevis. The species peaked in year four and again in year 11.

Gashwiler (1970) found that Oregon Voles were rare in mature Douglas-fir-Western Hemlock forest of Oregon, but invaded clearcut sites immediately after burning. Their populations peaked 4-5 years after the logging. Based on our small capture values for this species, populations peaked earlier in our study (age two) than those Gashwiler observed, but the species was still present in the age four stand.

Chipmunks of several species have generally been found to undergo rapid population increases following logging. For example, in mid-elevation Douglas-fir-Ponderosa Pine stands in Idaho, Medin (1987) found Yellow-Pine Chipmunks (*Tamias amoenus*) to be about twice as common in logged/burned sites of ages two and three years than in unlogged sites, and this species was codominant with *P. maniculatus* in stands of all ages studied. Similarly, Tevis (1956) observed an increase in populations of the Shadow Chipmunk (*Tamias senex*, listed as Townsend Chipmunk in the study) after logging, but noted that this species is one of the only species to remain in mature west-coast forests. Population levels of this species, however, were likely to be 2-4 times larger in stands of ages 3-10 years. The species disappeared if Tanbark Oak assumed dominance. These latter observations roughly parallel our findings for the Sonoma Chipmunk. It correlated most strongly with early site factors, but remained in the community throughout later stages.

We found few references concerning populations of Woodrats in coniferous forests or following logging, but Tevis (1956) caught Woodrats in areas in northern California where Douglas-fir had been logged. The eleven stands that he studied ranged in age from three months to 20 years, but data were not presented by year. Woodrats accounted for 3.2% of his total captures, compared with 14.6% in our study. It is possible that Tevis trapped more intensively in early ages than we did, which could account for his lower percentage of captures for this species. Tevis reported that this species is primarily folivorous, with Tanbark Oak as its preferred food. In our study, the Woodrat was somewhat more abundant in the 1984 site than in the 1980 site, but the Tanbark Oak cover values (Table 3) were three times higher in 1980. It is possible that single-species food utilization exists, but use of several species of shrubs and hardwoods is more likely.

In the longitudinal study of Douglas-fir-Western Hemlock forest of Oregon performed by Gashwiler (1970), Trowbridge Shrew also peaked at about the stand ages we observed, 5-10 years since logging in his study (data reported in this study end at year ten). Our data show continued presence at low numbers from ages 2 through 27, but absence in the 80-year-old stand.

The feeding habits of the Red-backed Vole are rather thoroughly understood, due largely to the work of Maser *et al.* (1978), who described the dependence the species has on the fruiting bodies of the hypogeous ectomycorrhizal fungi of mature conifers. Throughout its range, the Red-backed Vole occurs in coniferous forests, where it functions symbiotically with the fungi by dispersing their spores. Hayes and Cross (1987) found that presence of the voles was correlated with large logs, the overhang of which provided cover for the animal's runways. The older coniferous forests thus provide the Red-backed Vole with both the food and shelter that are its specialized requirements. It is not surprising, therefore, that a number of authors have found, as we did, that the species declines or disappears entirely in response to logging (Halvorson, 1982; Campbell and Clark, 1980; Maser *et al.*, 1978; and Tevis, 1956). We did catch ten members of this species in the two-year-old site, but all of these captures were from three trapping stations at one end of the site that had coniferous forest nearby.

Interactions among species that are associated with succession have also been described. Maser *et al.* (1978) noted that the Oregon Vole and Deer Mouse will eat hypogeous fungi, but depend primarily on forbs and grasses. As conifers invade a stand and mature, the Deer Mouse and Oregon Vole decline as the Red-backed Vole increases. Coexistence begins when fungi invade the stands as conifers grow, providing food for the Red-backed Vole, and ends when the herbaceous cover is lost due to the shade of the canopy. At this point, the Oregon Vole and Deer Mouse both decline because they compete poorly with the Red-backed Vole for both food and cover. Halvorson (1982) observed similar trends. It should also be noted that the Deer Mouse feeds on insects in both forested and logged habitats. Tevis (1956) found that 60% of the total volume of the contents of Deer Mouse stomachs from logged areas contained insects, while 44% of the volume of stomachs of this species from the forested areas consisted of this food type.

Higher population levels for the shrews in mid-aged stands very probably relate to abundance and continued seasonal ability of their insect prey. The age two stand did have shrews, but population levels appeared to be higher from ages four through 11. Increased diversity of plant species as the stands age may provide food more reliably on a year-round basis. The Trowbridge Shrew was not captured in the Control site, possibly because the sparse ground layer does not support sufficient prey populations.

Based on this sampling of the literature, an overview of how the autecology and interactions among species explain our observations can be presented. The Chipmunk has a preference for somewhat xeric areas, and is abundant in early sites. It correlated with downed wood, and may use the slash as a system of runways. Other early species include the Oregon Vole and Deer Mouse. The Deer Mouse is a generalist with a variety of foods and seems to tolerate many conditions of cover. As soon as sufficient food is available, both plant and animal, it invades the clearcuts and builds to a high level. The Oregon Vole invades very early, as soon as sufficient herbaceous plants exist to provide its food. By contrast, the Woodrat requires young woody plants for food, and possibly cover, thus its numbers are low until these species grow. Its populations remain high while these species are present, but decline when the conifers begin to assume dominance, a decline that is probably related to changes in the plant community. On the other hand, the Deer Mouse and Oregon Vole may be adversely affected by competition with the Red-backed Vole, which becomes a superior competitor once conifers have reached sufficient size to provide its fungal food. The insectivores are probably not affected strongly by competition with rodents, but respond to abundance and predictability of insect food. Coexistence of three insectivorous species suggests some differences in their patterns of habitat utilization.

Implications for Management

Small Mammal Diversity. In this study, small mammal diversity was considerably higher in the four youngest sites than in sites with a coniferous forest overstory, and peaked in the seven and 11-year-old stands. The number of plant species (based only on winter sampling) showed the same pattern. Four of the species of mammals that contributed to the high diversity of the mid-aged 1984 and 1980 stands (Deer Mouse, Meadow Vole, Woodrat, and Pacific Shrew) each had one or more significant correlations with non-conifer vegetative characteristics (Table 5). By contrast, the Trowbridge Shrew, a fifth mid-seral species, correlated only with conifers of 1-5 m among the plant variables. The ability of the sites we studied to support high mammalian diversity is quite probably related to the diverse plant communities that were established by natural invasion and succession. Stands of young trees managed strictly for conifers would not be expected to have met the requirements of as many mammals. Thomas *et* *al.* (1990) expressed this viewpoint, pointing out that the use of herbicides to suppress hardwoods would have an adverse affect on Woodrat populations. Additional data on sites of several ages that have been managed intensively to exclude hardwoods, shrubs, and vines would be valuable in testing this idea.

Since the oldest site of our study had an approximate age of 80 years, caution must be exercised in concluding that clearcutting enhances diversity. True old-growth stands of ages well over a hundred years might have higher diversity than our Control due to the variety of plant species found where openings have developed in the canopy. Studies of the mammals of these forests would be useful to complete the successional sequence presented here. At least one study provides some evidence that diversity may return in true old-growth stands: data from Raphael (1988) presented in Thomas *et al.* (1990) show Woodrat populations reaching higher levels in old stands than in the early-seral clearcuts, with a decline in the intervening years. Raphael's data on Deer Mouse also show populations to be higher in old growth as compared with mid-aged stands, but at levels considerably lower than on clearcut sites.

Small Mammals as a Prey Base for Predators. The notably higher biomass of small mammals in the young, open stands compared with the stands dominated by taller conifers indicates that the young cuts provide much greater potential food for predators. Data summarized by Thomas *et al.* (1990) indicate that the Woodrat is a primary prey item for the Northern Spotted Owl (*Strix occidentalis caurina*), generally comprising from 30 to 45 percent of its diet in Northern California. Since the Woodrat was only abundant on our four youngest sites, where it was the major reason for the high biomass figures, creation of clearcuts and then allowing them to revegetate naturally could be a useful tool for providing prey for Spotted Owls. Relying entirely on selective cutting in managed older stands may not produce the habitat the Woodrat needs unless the openings created by the logging are sufficiently large to facilitate extensive growth of shrubs and hardwoods.

A critical question on logging methods and the production of woodrats and other small mammals as prey is thus the size of the patch created. Below some minimum acreage, some species may not invade at all. With very small patches, they might invade but not produce a population large enough to provide a reliable source of prey, and thus not be well utilized by the predators.

The two sites where Woodrats were most abundant in our study, due to vegetative site factors discussed above, were also the two smallest. The 1984 site, which had the highest relative abundance, comprised nine acres, while the 1980 site, with the second highest population levels, was 11 acres in size. Small clearcuts of 5-15 acres should thus well serve the function of adding to the prey base of the Spotted Owl and other predators. Attention must be paid to the behavior of the predators in adopting such a management policy, however. Lynn Stafford (personal communication) suggested that a conifer canopy of at least 40 percent may be required before the Spotted Owl will forage in an area. Thus the abundant prey in young clearcuts may be utilized by this owl only when the rodents venture into the forested edges of the clearcuts, with predators like the Bobcat taking prey from the centers of the cuts.

The timing of successional events as they relate to the small mammals as prey is also important. There is a gap in our site ages from 11 to 27 years. Somewhere within this time span, habitats changed from being highly diverse and producing abundant prey to being dominated by a single species (the Red-backed Vole) at lower relative population levels and considerably lower biomass. Some longitudinal study of the existing sites would be valuable in identifying the point where the shift in habitat characteristics occurs, but 15-20 years seems a reasonable estimate. Conifers over five m comprised five percent of the cover of the 11 year old site, and rapid growth of these trees would lead to canopy closure within a few years, creating a pole timber stand such as found on our 1964 site. The report by Thomas *et al.* (1990) presents conflicting information on the value of such stands for woodrats. Data obtained by belt transect sampling for Woodrat houses taken from Sakai *et al.* (1989) show high abundance of Woodrats in pole timber stands, but data based on live trapping cited from Raphael (1988) conform to our observations that the Woodrat has low abundance in pole timber stands, but high populations in the preceding seral stage. We urge caution in the use of house-counting as a sole method for estimating Woodrat abundance, because the houses could represent a previously existing population that has declined or disappeared altogether as the canopy closes.

Once a nearly complete canopy has been formed, there is no apparent benefit for either small mammal diversity or biomass to allowing the stand to thin itself as opposed to thinning it deliberately. We observed approximately equivalent low population levels and diversities in the 27 and 80 year old stands, neither of which had been thinned. Indeed, management practices, such as a precommercial thinning at a stand age of about ten years, could prevent early canopy closure and possibly extend the period of higher diversity and population levels in small mammals. However, we advise that the 1964 site itself remain unmodified for possible use in future studies.

The overall pattern in our data is one in which a relatively short burst of small mammal diversity and abundance, lasting about 20 years, is followed by a long period in which both diversity and abundance are low. As just noted, the endpoint for this phase, if it has one, was not determinable in our study because true old-growth stands did not exist for comparison. It would seem prudent, however, to accentuate diversity in areas designated for wood production by creating occasional 5-15 acre clearcut patches, even if this meant that some trees were cut before their optimal size for timber production had been met.

Patterns of Dispersal to Clearcut Areas. The ability of a variety of small mammals to locate the habitats created in our study areas depended on unknown patterns of movement within a broader area, and no data exist on what the major corridors for such movement were. If naturally revegetating clearcuts are to serve as a means of enhancing diversity, the species must obviously be able to find them. The various studies cited above suggest that this may rarely be a problem, since similar population trends have been observed in a variety of areas. Additional work on the problem of dispersal of the small mammals would be extremely valuable, however, if management of their populations becomes an explicit goal of foresters.

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APPENDIX A-SUMMARY DATA ON TRAPPING STATIONS

Table A-1. Winter and summer trapping data. Abbreviations: Ev.=evidence of trap visitation. RV=Red-backed Vole, DM=Deer Mouse, WR=Woodrat, PS= Pacific Shrew, TS=Trowbridge Shrew, SM=Shrew Mole, OV=Oregon Vole, JM=Jumping Mouse, CM=Chipmunk, MV=Meadow Vole.

Site	Seas	Stn	Ev.	#Sp	RV	DM	WR	PS	TS	SM	OV	JM	CM	MV
Con	Win	1a	3	1	3									
Con	Sum	1a	1	1		1								
Con	Win	1b	2	2	1	1								
Con	Sum	1b		2	1	1								
Con	Win	2a	1											
Con	Sum	2a												
Con	Win	2b		1	2									
Con	Sum	2b	1	1	1									
Con	Win	3a												
Con	Sum	3a		1	2									
Con	Win	3b	2											
Con	Sum	3b	2											
Con	Win	4a	1	1	1									
Con	Sum	4a	1											
Con	Win	4b		1	1									
Con	Sum	4b	2											
Con	Win	5a	1	1	1									
Con	Sum	5a	1	1	1									
Con	Win	5b	1											
Con	Sum	5b	2											
Con	Win	6a		1	1									
Con	Sum	6a	3											
Con	Win	6b	1	1	2									
Con	Sum	6b		1	2									
Con	Win	7a	1		2									
Con	Sum	7a												
Con	Win	7b												
Con	Sum	7b			3									
Con	Win	8a												
Con	Sum	8a		1	1									
Con	Win	8b		1	1									
Con	Sum	8b		1	1									
Con	Win	9a	1	1	1									
Con	Sum	9a		1	2									
Con	Win	9b	1	1	2									
Con	Sum	9b		2	1			1						
Con	Win	10a		2	4	1								
Con	Sum	10a		2	1								1	

Table A-1. Winter and summer trapping data, continued.

Site	Seas	Stn	Ev.	#Sp	RV	DM	WR	PS	TS	SM	OV	JM	CM	MV
Con	Win	10b	1	1	2									
Con	Sum	10b												
Con	Win	11a	1	1	2									
Con	Sum	11a	2											
Con	Win	11b	2	1	1									
Con	Sum	11b	1											
Con	Win	12a	1	2	1			1						
Con	Sum	12a	2											
Con	Win	12b		2	1	1								
Con	Sum	12b												
Con	Win	13a	3											
Con	Sum	13a	1											
Con	Win	13b	2											
Con	Sum	13b												
Con	Win	14a	2	1	1									
Con	Sum	14a	1											
Con	Win	14b	2	1	2									
Con	Sum	14b	2											
Con	Win	15a		1	1									
Con	Sum	15a	2	1	1									
Con	Win	15b		1	1									
Con	Sum	15b	1	1	3									
1964	Win	1a	1	1	2									
1964	Sum	1a	2	1	1									
1964	Win	1b	1	2	2	1								
1964	Sum	1b	3											
1964	Win	2a		1	1									
1964	Sum	2a	3											
1964	Win	2b	2	1		1								
1964	Sum	2b	1	1									1	
1964	Win	3a		1	1									
1964	Sum	3a	1											
1964	Win	3b		1	1	1								
1964	Sum	3b	2	1	1				1					
1964	Win	4a		2	3	1								
1964	Sum	4a	1	2	1				1					
1964	Win	4b	1											
1964	Sum	4b							1					
1964	Win	5a	1	1	1									
1964	Sum	5a	2						1					

Table A-1. Winter and summer trapping data, continued.

Site	Seas	Stn	Ev.	#Sp	RV	DM	WR	PS	TS	SM	OV	JM	CM	MV
1964	Win	5b												
1964	Sum	5b	2	1					1					
1964	Win	6a	1	1	1									
1964	Sum	6a												
1964	Win	6b												
1964	Sum	6b	1	2	1				1					
1964	Win	7a												
1964	Sum	7a												
1964	Win	7b		1	2									
1964	Sum	7b	1											
1964	Win	8a	1											
1964	Sum	8a	1											
1964	Win	8b												
1964	Sum	8b		2	1								1	
1964	Win	9a	1	1	1									
1964	Sum	9a		2	1								1	
1964	Win	9b												
1964	Sum	9b		1	1									
1964	Win	10a		1	5									
1964	Sum	10a												
1964	Win	10b												
1964	Sum	10b	1	2	1							1		
1964	Win	11a	1	1	1									
1964	Sum	11a	1	1	1									
1964	Win	11b		1	1									
1964	Sum	11b	1	1	2									
1964	Win	12a		1	2									
1964	Sum	12a		1	1									
1964	Win	12b	1	1	2									
1964	Sum	12b	3											
1964	Win	13a	1											
1964	Sum	13a	1											
1964	Win	13b												
1964	Sum	13b	1										1	
1964	Win	14a	1	1	1									
1964	Sum	14a		2	2								1	
1964	Win	14b		1	2									
1964	Sum	14b	1	2	1								1	
1964	Win	15a	1	1									1	
1964	Sum	15a												

Table A-1. Winter and summer trapping data, continued.

Site	Seas	Stn	Ev.	#Sp	RV	DM	WR	PS	TS	SM	OV	JM	CM	MV
1964	Win	15b	1										1	
1964	Sum	15b	1											
1980	Win	1a	1	2	1	1								
1980	Sum	1a	1	1		4								
1980	Win	1b	3	1		2								
1980	Sum	1b	3	1		1								
1980	Win	2a												
1980	Sum	2a		1	2									
1980	Win	2b	5											
1980	Sum	2b												
1980	Win	3a		1	2									
1980	Sum	3a	1	1			1							
1980	Win	3b	1	1		2								
1980	Sum	3b		1		2								
1980	Win	4a	1	1		2								
1980	Sum	4a	1	1			2							
1980	Win	4b	3	1		1								
1980	Sum	4b	1	2		2	1							
1980	Win	5a		2		2			1					
1980	Sum	5a	1	2		1	1							
1980	Win	5b	1	2	1	1								
1980	Sum	5b	2	1		1								
1980	Win	6a	1	3	1		1		1					
1980	Sum	6a	2	1			1							
1980	Win	6b	2	1	1									
1980	Sum	6b		2		1		1						
1980	Win	7a	1	2		1	1							
1980	Sum	7a	1	1	1									
1980	Win	7b		3	1		1	1						
1980	Sum	7b		2	1		1							
1980	Win	8a	3											
1980	Sum	8a	2	1	3									
1980	Win	8b	3	1		1								
1980	Sum	8b	1	2	2		1							
1980	Win	9a	1	3	2	1	1							
1980	Sum	9a	3	1									1	
1980	Win	9b	3	2	1	2								
1980	Sum	9b	1	2	2	3								
1980	Win	10a	1	2	1	4								
1980	Sum	10a	1	2		3	1							
1980	Win	10b	1	3	1	2	1							
1980	Sum	10b	2	1		2								

Table A-1. Winter and summer trapping data, continued.

Site	Seas	Stn	Ev.	#Sp	RV	DM	WR	PS	TS	SM	OV	JM	CM	MV
1980	Win	11a		2		3		1						
1980	Sum	11a	2	3		1			1				1	
1980	Win	11b		2	1		2							
1980	Sum	11b	2	2		1	1							
1980	Win	12a	1	2	1		1							
1980	Sum	12a		3		2	1						2	
1980	Win	12b	2	1		2								
1980	Sum	12b		2	3	1								
1980	Win	13a	3											
1980	Sum	13a	2											
1980	Win	13b	2	2	1		1							
1980	Sum	13b		3	1	1					1			
1980	Win	14a	2	1		2								
1980	Sum	14a	2	2	1	1								
1980	Win	14b	1	1	1									
1980	Sum	14b	3	1						1				
1980	Win	15a		2		2	1							
1980	Sum	15a		2		2							2	
1980	Win	15b	2	3	2	1	1							
1980	Sum	15b	1	2	2	1								
1984	Win	1a	2	2		1	1							
1984	Sum	1a		1									1	
1984	Win	1b	2	2		2								
1984	Sum	1b		2			1						1	
1984	Win	2a	2	1			1							
1984	Sum	2a	1	2		1	1							
1984	Win	2b	3	1										1
1984	Sum	2b	1	2		1	1							
1984	Win	3a	2	1			1							
1984	Sum	3a		3		1	1							2
1984	Win	3b	2	3		2		2						
1984	Sum	3b	1	1		2								
1984	Win	4a		2		3	3							
1984	Sum	4a	2	2		3	1							
1984	Win	4b	4	1		1								
1984	Sum	4b		2			1		1					
1984	Win	5a	3	2		2								
1984	Sum	5a	1	1			1							
1984	Win	5b	1											
1984	Sum	5b		2			1						1	

Table A-1. Winter and summer trapping data, continued.

Site	Seas	Stn	Ev.	#Sp	RV	DM	WR	PS	TS	SM	OV	JM	CM	MV
1984	Win	6a	1	3		1	1		1					
1984	Sum	6a		2			2	1						
1984	Win	6b	3	1										2
1984	Sum	6b		1					1					
1984	Win	7a	2	2		1		1						
1984	Sum	7a	1	1			2							
1984	Win	7b		1			2							
1984	Sum	7b		2			4						1	
1984	Win	8a	2											
1984	Sum	8a	2											
1984	Win	8b	1											
1984	Sum	8b	1	1		1								
1984	Win	9a	1											
1984	Sum	9a		1		2								
1984	Win	9b		1					1					
1984	Sum	9b	2											
1984	Win	10a	1	2		1	1							
1984	Sum	10a	2	2		2	1							
1984	Win	10b	2											
1984	Sum	10b	1	2		1	2							
1984	Win	11a	3	1			2							
1984	Sum	11a		1			2							
1984	Win	11b	2	2		2	1							
1984	Sum	11b	1	1			2							
1984	Win	12a		1			1							
1984	Sum	12a	2	2				1	1					
1984	Win	12b	3	1	1									
1984	Sum	12b	2	2		1	1							
1984	Win	13a	4											
1984	Sum	13a	1	1		1								
1984	Win	13b	1	2			2		1					
1984	Sum	13b	2	2		2	1							
1984	Win	14a	2											
1984	Sum	14a	1	1						2				
1984	Win	14b	1											
1984	Sum	14b	1											
1984	Win	15a	3	2		1		1						
1984	Sum	15a		1			2							
1984	Win	15b	2	2	1				1					
1984	Sum	15b		1			2							

Table A-1. Winter and summer trapping data, continued.

Site	Seas	Stn	Ev.	#Sp	RV	DM	WR	PS	TS	SM	OV	JM	CM	MV
1987	Win	1a	1	2		2	1							
1987	Sum	1a	1	2		3							1	
1987	Win	1b	3	1		2								
1987	Sum	1b	1	2		1							2	
1987	Win	2a	4											
1987	Sum	2a	1	3		1					1		1	
1987	Win	2b	3											
1987	Sum	2b	2	1									1	
1987	Win	3a	2	1			2							
1987	Sum	3a		1		1								
1987	Win	3b		1		1								
1987	Sum	3b		1		1								
1987	Win	4a	1	1		2								
1987	Sum	4a	1	1		2								
1987	Win	4b	1	1		5								
1987	Sum	4b	1	1		3								
1987	Win	5a		1		1								
1987	Sum	5a		2		1	1							
1987	Win	5b	1	1		1								
1987	Sum	5b		1		2								
1987	Win	6a	1	1		2								
1987	Sum	6a		3		1		1					1	
1987	Win	6b	2	1		3								
1987	Sum	6b	1	3		2			1				1	
1987	Win	7a		1		1								
1987	Sum	7a	2	2			2						1	
1987	Win	7b		1		2								
1987	Sum	7b		1		1							1	
1987	Win	8a	2											
1987	Sum	8a		1			1							
1987	Win	8b	1	1		2								
1987	Sum	8b	2	2		2							1	
1987	Win	9a	1	1		1								
1987	Sum	9a		1		3								
1987	Win	9b	1											
1987	Sum	9b	1	1		1								
1987	Win	10a	1	1		3								
1987	Sum	10a		3		2					1		1	
1987	Win	10b		1										1
1987	Sum	10b	1	1		1								

Table A-1. Winter and summer trapping data, continued.

Site	Seas	Stn	Ev.	#Sp	RV	DM	WR	PS	TS	SM	OV	JM	CM	MV
1987	Win	11a		2		1	2							
1987	Sum	11a	1	1			2							
1987	Win	11b												
1987	Sum	11b	1	1		1								
1987	Win	12a	2	1			1							
1987	Sum	12a		1					1					
1987	Win	12b		1		4								
1987	Sum	12b	2	2		3			1					
1987	Win	13a	2											
1987	Sum	13a	1	1		3								
1987	Win	13b	3	1			1							
1987	Sum	13b	2	1		3								
1987	Win	14a	1	2		2								1
1987	Sum	14a		1		3								
1987	Win	14b		2		2					1			
1987	Sum	14b	3	2		1							1	
1987	Win	15a	1	2		3	1							
1987	Sum	15a		2		1	2							
1987	Win	15b		1		4								
1987	Sum	15b	1	3		1			2				1	
1989	Win	1a	3	1									1	
1989	Sum	1a		2		2							2	
1989	Win	1b		1		3								
1989	Sum	1b	2	1		1								
1989	Win	2a	2											
1989	Sum	2a	1	1		2								
1989	Win	2b	1	1		1								
1989	Sum	2b	1	1		1								
1989	Win	3a	1	1		2								
1989	Sum	3a	3	1		2								
1989	Win	3b	2	1									1	
1989	Sum	3b		1		2								
1989	Win	4a	1											
1989	Sum	4a	1	3		1		1					2	
1989	Win	4b	1											
1989	Sum	4b	1	1				1						
1989	Win	5a	1											
1989	Sum	5a		1		1								
1989	Win	5b												
1989	Sum	5b	1	2		1							2	

Table A-1. Winter and summer trapping data, continued.

Site	Seas	Stn	Ev.	#Sp	RV	DM	WR	PS	TS	SM	OV	JM	CM	MV
1989	Win	6a	2	3				1			1			1
1989	Sum	6a	1	1									1	
1989	Win	6b		1		1								
1989	Sum	6b	3	1									1	
1989	Win	7a	2											
1989	Sum	7a	1	2		2							2	
1989	Win	7b	1	1			2							
1989	Sum	7b	1	2		2	2							
1989	Win	8a	2	2		1					1			
1989	Sum	8a		2		2			1					
1989	Win	8b	2											
1989	Sum	8b		3			1		1				1	
1989	Win	9a	1											
1989	Sum	9a		2		2							1	
1989	Win	9b	4											
1989	Sum	9b	1	1									1	
1989	Win	10a		1		6								
1989	Sum	10a		1		5								
1989	Win	10b		2		1					1			
1989	Sum	10b		1							1			
1989	Win	11a												
1989	Sum	11a	1											
1989	Win	11b	2	1		2								
1989	Sum	11b	1	1		4								
1989	Win	12a	1	1		1								
1989	Sum	12a	2	1		4								
1989	Win	12b	1	2		1								2
1989	Sum	12b		2		3							1	
1989	Win	13a	1	2							1			
1989	Sum	13a		1									2	
1989	Win	13b	2	1		1								
1989	Sum	13b	2	2		1							1	
1989	Win	14a	1	1		1								
1989	Sum	14a	2	1		1								
1989	Win	14b	1	1	1									
1989	Sum	14b	2	1	2									
1989	Win	15a	1	1	2									
1989	Sum	15a	1	1		1								
1989	Win	15b	1	1	3									
1989	Sum	15b		2	2	1								

Table A-2. Data on site factors of stations. All data were based on winter sampling. Abbreviations: Seas=season, Stn=station, Sl=slope (%), BG=bare ground (% cover). Slash values are % cover: TSlsh=total slash, SmSls=small slash, MdSls=medium slash, and LgSls=large slash, as defined in methods on p. 6. Slash depth in cm: SmDep=small slash depth, MdDep=medium slash depth, LgDep=large slash depth.

Site	Seas	Stn	Sl	BG	Stmp	TSlsh	SmSls	SmDep	MdSls	MdDep	LgSls	LgDep
Con	Win	1a	27	2.25	0	37.5	16.25	9	12.5	30	8.75	55
Con	Win	1b	14	0.25	0	55	47.5	0	7.5	20	0	0
Con	Win	2a	35	0.25	0	18.5	11.25	5.7	6.25	15	0	0
Con	Win	2b	63	0.5	0	3.75	3.75	7	0	0	0	0
Con	Win	3a	23	0	0	6.25	1.25	5	5	11.5	0	0
Con	Win	3b	41	2.5	0	50	0	0	0	0	50	100
Con	Win	4a	24	0	0	10	0	0	2.5	5	7.5	60
Con	Win	4b	33	0	0	10	10	9.25	0	0	0	0
Con	Win	5a	42	1.25	0	20	2.5	6	17.5	21.7	0	0
Con	Win	5b	31	1.25	0	12.5	3.75	6.5	8.75	16.5	0	0
Con	Win	6a	56	0	0	11.25	11.25	12.7	0	0	0	0
Con	Win	6b	60	0	0	15.25	3.75	11	0	0	12.5	150
Con	Win	7a	51	0	0	5	5	6.5	0	0	0	0
Con	Win	7b	46	0	0	3	3	14	0	0	0	0
Con	Win	8a	54	0	0	26.25	13.75	7	12.5	15	0	0
Con	Win	8b	54	0	0	16.25	0	0	0	0	16.25	27.5
Con	Win	9a	47	0	0	12.6	2.5	6	3.8	14	6.3	20
Con	Win	9b	18	16.25	12.5	2.5	2.5	5	0	0	0	0
Con	Win	10a	31	0	0	33.75	1.25	5	0	0	32.5	70
Con	Win	10b	30	0	1.25	3.75	3.75	3.5	0	0	0	0
Con	Win	11a	43	0	0	25	0	0	5	15	20	65
Con	Win	11b	42	0	0	4	2.75	3	1.25	10	0	0
Con	Win	12a	27	0	0	23.75	6.25	16.5	0	0	17.5	30
Con	Win	12b	41	0	0	17.5	12.5	4.7	0	0	5	10
Con	Win	13a	22	0	0	8	5.5	5	2.5	15	0	0
Con	Win	13b	30	0	0	20	20	12.75	0	0	0	0
Con	Win	14a	28	0	0	13.75	10	7.6	3.75	15	0	0
Con	Win	14b	34	0	0	18.25	12	9.6	6.25	18	0	0
Con	Win	15a	28	1.25	1.25	9	0.25	4	8.75	11.6	0	0
Con	Win	15b	43	1.25	0	3.25	3.25	4	0	0	0	0
1964	Win	1a	10	0	0	35	8.75	15	16.25	20	10	23
1964	Win	1b	3	3	0	43.75	36.25	24	7.5	24	0	0
1964	Win	2a	14	3.25	0	33.75	0	0	8.75	14.5	25	30
1964	Win	2b	20	0	0	41.25	0	0	31.25	19	10	30
1964	Win	3a	13	4.5	0	40	16.25	11	23.75	25	0	0
1964	Win	3b	5	0	10	75	37.5	30	18.75	30	18.75	37
1964	Win	4a	10	0	1.25	23.75	16.25	27	0	0	7.5	28
1964	Win	4b	12	0	2	35	22.5	15	0	0	12.5	50

Table A-2. Data on site factors of stations, continued.

Site	Seas	Stn	SI	BG	Stmp	TSlsh	SmSls	SmDep	MdSls	MdDep	LgSlsh	LgDep
1964	Win	5a	26	2	0	22.5	7.5	2	15	12.3	0	0
1964	Win	5b	24	0	0	25	15	10.5	10	15.5	0	0
1964	Win	6a	21	0	18.75	6.75	4.25	3.66	2.5	25	0	0
1964	Win	6b	15	0	0	12.5	1.25	20	5	10	6.25	25
1964	Win	7a	20	0	0	65	65	100	0	0	0	0
1964	Win	7b	29	0.375	0	75	25	120	50	21.6	0	0
1964	Win	8a	29	0.75	28.75	41.25	41.25	73.3	0	0	0	0
1964	Win	8b	17	0.5	0	40	36.25	75	3.75	18	0	0
1964	Win	9a	47	0	0	10	10	6.87	0	0	0	0
1964	Win	9b	25	0.25	0	8.5	3.5	5.66	0	0	5	15
1964	Win	10a	53	22.5	8.75	12.5	11.25	9	0	0	1.25	12
1964	Win	10b	20	1.5	12.5	25	25	53.66	0	0	0	0
1964	Win	11a	16	0	0	50	37.5	100	0	0	12.5	30
1964	Win	11b	26	0	0	90	90	121.25	0	0	0	0
1964	Win	12a	27	0.88	0	30	30	33.75	0	0	0	0
1964	Win	12b	34	0	0	16.25	0	0	16.25	21	0	0
1964	Win	13a	20	0	38.75	12.5	0	0	0	0	12.5	27.5
1964	Win	13b	35	0	0	66.25	66.25	123.75	0	0	0	0
1964	Win	14a	36	26.25	0	32.5	0	0	0	0	32.5	67.5
1964	Win	14b	*	0	0	52.5	52.5	42.5	0	0	0	0
1964	Win	15a	50	0	0	37.5	0	0	21.25	95	16.25	67.5
1964	Win	15b	56	0	0.5	0.25	0	0	0.25	10	0	0
1980	Win	1a	47	6.25	12.5	3.75	3.75	11	0	0	0	0
1980	Win	1b	33	5	0	13.75	13.75	12.5	0	0	0	0
1980	Win	2a	52	10.25	8.75	1.25	1.25	5	0	0	0	0
1980	Win	2b	37	6.25	0	40	30	13.33	10	30	0	0
1980	Win	3a	46	0	8.75	3.75	1.25	10	2.5	7.5	0	0
1980	Win	3b	39	16.25	0	11.25	7.5	6.67	3.75	10	0	0
1980	Win	4a	20	0	27.5	1.25	0	0	0	0	1.25	300
1980	Win	4b	75	6.25	0	0	0	0	0	0	0	0
1980	Win	5a	13	0	0	0	0	0	0	0	0	0
1980	Win	5b	72	0	20	57.5	57.5	22.5	0	0	0	0
1980	Win	6a	29	0	0	12.75	5	20	7.5	27.5	0	0
1980	Win	6b	38	2.5	5	0	0	0	0	0	0	0
1980	Win	7a	45	3.75	5	20	7.5	10	5	30	7.5	40
1980	Win	7b	26	0	0	25	1.25	12	23.75	45	0	0
1980	Win	8a	35	2.5	7.5	0	0	0	0	0	0	0
1980	Win	8b	35	0	0	6.25	6.25	5.66	0	0	0	0
1980	Win	9a	52	7	0	21.25	21.25	10	0	0	0	0
1980	Win	9b	25	0	0	58.75	22.5	35	36.25	38.33	0	0

Table A-2. Data on site factors of stations, continued.

Site	Seas	Stn	Sl	BG	Stmp	TSlsh	SmSls	SmDep	MdSls	MdDep	LgSls	LgDep
1980	Win	10a	42	0	25	75	50	47.5	25	60	0	0
1980	Win	10b	24	8	1.25	20.5	0	0	20.5	21.75	0	0
1980	Win	11a	35	2.5	0	30	0	0	30	23.33	0	0
1980	Win	11b	66	0	0	45	0	0	0	0	45	45
1980	Win	12a	56	7.5	0	1.25	0	0	1.25	3	0	0
1980	Win	12b	33	0	3.75	23.5	13.5	14.33	10	20	0	0
1980	Win	13a	*	0	0	0	0	0	0	0	0	0
1980	Win	13b	28	30	0	0.25	0.25	5	0	0	0	0
1980	Win	14a	22	7.75	0	40	0	0	40	25	0	0
1980	Win	14b	30	0	0	0.75	0.75	0.25	0	0	0	0
1980	Win	15a	45	0	0	18.75	3.75	20	6.25	40	8.75	30
1980	Win	15b	25	6.25	0	5	5	11.25	0	0	0	0
1984	Win	1a	11	0	0	63.75	45	25	0	0	18.75	45
1984	Win	1b	16	0.75	0	23.75	15	14.3	8.75	15	0	0
1984	Win	2a	14	17.5	33.75	20	13.75	15	6.25	20	0	0
1984	Win	2b	94	25	0	13.75	6.25	8.5	7.5	15	0	0
1984	Win	3a	5	5	8.75	6.25	2.5	10	3.75	25	0	0
1984	Win	3b	14	3.75	0	38.75	0	0	38.75	20.6	0	0
1984	Win	4a	4	23.75	0	7.5	0	0	7.5	17.5	0	0
1984	Win	4b	3	12.5	0	18.75	12.5	15	6.25	20	0	0
1984	Win	5a	7	0	10	91.25	0	0	91.25	55	0	0
1984	Win	5b	16	35.75	0	0.028	0.028	11.25	0	0	0	0
1984	Win	6a	11	5	0	35	12.5	30	22.5	19.6	0	0
1984	Win	6b	16	3.75	0	22.5	0	0	22.5	17	0	0
1984	Win	7a	16	11.25	0	30	0	0	30	19.25	0	0
1984	Win	7b	14	3.75	0	38.75	8.75	5	30	20	0	0
1984	Win	8a	30	7.5	25	33.75	15	10	0	0	18.75	96
1984	Win	8b	12	18.75	0	15.01	8.76	7.6	6.25	20	0	0
1984	Win	9a	10	21.25	0	26.25	11.25	7.5	12.5	20	2.5	2
1984	Win	9b	15	1.25	0	80	60	20	20	30	0	0
1984	Win	10a	26	0	0	48.75	0	0	7.5	66	41.25	81.67
1984	Win	10b	13	15	0	13.75	6.25	10	6.25	20	1.25	45
1984	Win	11a	15	2.5	3.75	60	11.25	15	48.75	33.3	0	0
1984	Win	11b	14	0	0	83.75	60	21.6	23.75	60	0	0
1984	Win	12a	20	0	0	51.25	12.5	20	38.75	40	0	0
1984	Win	12b	19	1.25	10	31.25	31.25	13.75	0	0	0	0
1984	Win	13a	20	56.25	0	6.25	6.25	4.75	0	0	0	0
1984	Win	13b	16	0	11.25	31.75	0	0	31.75	22.5	0	0
1984	Win	14a	17	3.75	0	30	2.5	15	7.5	17.5	20	100
1984	Win	14b	8	0	0	8.75	0	0	8.75	17.5	0	0

Table A-2. Data on site factors of stations, continued.

Site	Seas	Stn	Sl	BG	Stmp	TSlsh	SmSls	SmDep	MdSls	MdDep	LgSls	LgDep
1984	Win	15a	9	25	3.75	15	10	6.6	5	20	0	0
1984	Win	15b	15	0	0	56.25	0	0	56.25	26.25	0	0
1987	Win	1a	44	0	0	100	0	0	0	0	100	50
1987	Win	1b	30	8.75	0	52.5	27.5	37.5	0	0	25	42.5
1987	Win	2a	42	1.25	0	98.7	98.7	22.5	0	0	0	0
1987	Win	2b	30	0	0	75	25	60	50	56.5	17.5	75
1987	Win	3a	33	2.5	25	57.5	32.5	17.5	25	30	0	0
1987	Win	3b	39	0	25	41.25	41.25	18.3	0	0	0	0
1987	Win	4a	48	0	0	85	60	31.66	25	50	0	0
1987	Win	4b	42	6.25	10	46.25	18.75	20	20	20	7.5	40
1987	Win	5a	57	0	0	90	20	30	45	59	25	90
1987	Win	5b	45	1.25	2.5	41.25	28.75	35	12.5	80	0	0
1987	Win	6a	26	0	0	87.5	22.5	52	0	0	65	73
1987	Win	6b	45	0	0	94.5	23.75	55	46.25	55	24.5	48
1987	Win	7a	50	0	0	93.25	47	26	0	0	46.25	43.5
1987	Win	7b	45	0	0	77.5	41.25	25	36.25	37	0	0
1987	Win	8a	75	1.25	2.5	95	75	75	20	30	0	0
1987	Win	8b	35	0	0	100	0	0	100	41.25	0	0
1987	Win	9a	52	7.5	10	73.75	73.75	17.5	0	0	0	0
1987	Win	9b	23	0	55	16.25	13.75	10.67	2.5	10	0	0
1987	Win	10a	25	0	6.25	87.5	20	13.5	20	23	17.5	65
1987	Win	10b	23	0	0	95	25	20	50	25	20	50
1987	Win	11a	25	0	0	100	50	20	50	25	0	0
1987	Win	11b	25	25	0	70	32.5	18.5	37.5	35	0	0
1987	Win	12a	51	1.25	3.75	40	0	0	40	40	0	0
1987	Win	12b	34	2.5	2.5	37.5	7.5	5	30	36.67	0	0
1987	Win	13a	42	8.75	7.5	65	22.5	10	42.5	27.5	0	0
1987	Win	13b	27	11.5	2.5	52.5	52.5	11.25	0	0	0	0
1987	Win	14a	34	0	0	100	0	0	100	50	0	0
1987	Win	14b	52	0	0	100	0	0	100	70.75	0	0
1987	Win	15a	31	0	0	76.25	76.25	14.25	0	0	0	0
1987	Win	15b	71	0	0	100	25	32	50	52.5	0	0
1989	Win	1a	39	0	0	100	50	67.5	25	30	25	50
1989	Win	1b	39	0	25	100	75	31.67	25	25	0	0
1989	Win	2a	45	0	6.25	76.25	10	8	66.25	36	0	0
1989	Win	2b	54	0	15	85	25	65	25	100	35	100
1989	Win	3a	39	0	0	100	50	9	50	30	0	0
1989	Win	3b	35	3.7	11.25	85	13.75	18	0	0	71.25	63.33
1989	Win	4a	34	0	15	85	63.75	16.67	21.25	15	0	0
1989	Win	4b	52	3.75	6.25	90	40	27.5	25	50	25	70
1989	Win	5a	46	11.25	0	88.75	43.75	27.5	0	0	45	58.75
1989	Win	5b	44	0	0	100	50	35	50	35	0	0

Table A-2. Data on site factors of stations, continued.

Site	Seas	Stn	SI	BG	Stmp	TSlsh	SmSls	SmDep	MdSls	MdDep	LgSls	LgDep
1989	Win	6a	21	17.5	5	77.5	40	16.5	37.5	15	0	0
1989	Win	6b	25	23.8	1.25	78.75	78.75	18.25	0	0	0	0
1989	Win	7a	20	0	25	75	50	32.5	25	40	0	0
1989	Win	7b	36	0	1.25	98.75	98.75	18.5	0	0	0	0
1989	Win	8a	10	0	2.5	96.25	48.75	35	47.5	72.5	0	0
1989	Win	8b	35	6.25	0	93.75	0	0	50	37.5	43.75	67.5
1989	Win	9a	35	2.5	20	77.5	12.5	10	25	30	40	77.5
1989	Win	9b	30	0	5	100	25	75	75	100	0	0
1989	Win	10a	14	23.75	1.25	18.75	0	0	18.75	15	0	0
1989	Win	10b	28	0	6.25	100	75	23.33	25	15	0	0
1989	Win	11a	3	42.5	12.5	25	25	10	0	0	0	0
1989	Win	11b	30	0	0	97.5	72	2.67	25	30	0	0
1989	Win	12a	36	0	0	100	50	37.5	50	55	0	0
1989	Win	12b	31	30	8.75	51.25	8.75	4	42.5	27.5	0	0
1989	Win	13a	38	11.5	12.5	87.5	45	40	42.5	55	0	0
1989	Win	13b	46	3.75	6.25	87.5	25	10	46.25	42.5	16.25	45
1989	Win	14a	24	32.5	28.75	78.75	38.75	22.5	40	85	0	0
1989	Win	14b	30	40	0	55	37.5	9	5	30	12.5	60
1989	Win	15a	56	8.75	0	65	62.5	10	58.75	53.33	0	0
1989	Win	15b	17	1.25	0	55	12.5	30	42.5	31.67	0	0

Table A-3. Summary of vegetative site factors by station. See methods (p. 6) to clarify categories.

Ste	Sea	Stn	No Sp	Frn	Hrb	Grs	Wtl Sp	Shrubs 0-1	Shrubs 1-5	Broadleaf Trees 0-1	Broadleaf Trees 1-5	Broadleaf Trees >5	Conifers 0-1	Conifers 1-5	Conifers >5	Tot Cov
Con	Win	1a	2	1.3	1.3											2.5
Con	Win	1b	3	1.3	1.3										0.34	2.8
Con	Win	2a	2	8.8											0.70	9.5
Con	Win	2b	4	3.8	2.5									16.60		24.4
Con	Win	3a	3		3.0					0.8					0.05	3.8
Con	Win	3b	3	8.8	5.0					8.8						22.5
Con	Win	4a	3	7.5	11.3								1.3		1.28	21.3
Con	Win	4b	2		2.5								2.5		0.80	5.8
Con	Win	5a	3	21.3				10.0		0.8						32.0
Con	Win	5b	3	20.0	5.0										1.10	26.1
Con	Win	6a	4	6.3	6.8					0.3					6.72	20.0
Con	Win	6b	3	4.3	3.0								10.7		1.13	9.4
Con	Win	7a	6	5.0	0.8	1.3		8.8							0.65	16.4
Con	Win	7b	4	11.8	1.8								12.5		5.41	31.4
Con	Win	8a	3		5.5									6.25		11.8
Con	Win	8b	5	17.5	11.3	5.3		1.3		3.8						39.0
Con	Win	9a	3	28.8	9.5										0.01	38.3
Con	Win	9b	3	26.3	8.8								3.8	27.50	0.04	66.3
Con	Win	10a	3	50.0				6.3			12.5					68.8
Con	Win	10b	9	8.8	9.0	6.3		6.3					1.3		1.90	34.2
Con	Win	11a	1	62.5												62.5
Con	Win	11b	3	30.0	6.3										0.64	36.9
Con	Win	12a	2	31.5	1.8											33.3
Con	Win	12b	3	22.5	1.0										1.88	212.2
Con	Win	13a	3	46.3	32.5											80.0
Con	Win	13b	3	50.0	5.3										0.15	55.4
Con	Win	14a	3	17.5						2.0					0.32	19.8
Con	Win	14b	5	9.3	2.5			2.3							3.97	18.0
Con	Win	15a	6	15.0	8.8			0.5			6.3		0.5		8.53	39.5
Con	Win	15b	3	12.3						1.0					0.37	13.6
1964	Win	1a	3	3.3											0.46	3.7
1964	Win	1b	3	0.8									0.3		0.42	1.4
1964	Win	2a	2											0.03	0.16	0.2
1964	Win	2b	4	6.5										7.50	0.71	14.7
1964	Win	3a	7	7.5	1.0			0.3						0.30	0.01	9.0
1964	Win	3b	1	1.8												1.8
1964	Win	4a	3										1.3		1.56	2.8
1964	Win	4b	2	0.3											1.68	1.9

Table A-3. Summary of vegetative site factors by station, continued.

Ste	Sea	Stn	No Sp	Frn	Hrb	Grs	Wtl Sp	Shrubs 0-1	Shrubs 1-5	Broadleaf Trees 0-1	Broadleaf Trees 1-5	Broadleaf Trees >5	Conifers 0-1	Conifers 1-5	Conifers >5	Tot Cov
1964	Win	5a	2	0.5											0.56	1.1
1964	Win	5b	5	1.0	0.3			3.8					0.3		0.11	5.4
1964	Win	6a	1												1.99	2.0
1964	Win	6b	5	5.0	1.0	0.3									0.77	7.0
1964	Win	7a	3	0.3	0.5									1.22	1.59	3.6
1964	Win	7b	6	3.3	0.3			0.3		17.8					1.94	21.7
1964	Win	8a	1	0.8												0.8
1964	Win	8b	6	12.0	1.8								0.3			18.9
1964	Win	9a	3	14.8											0.89	15.7
1964	Win	9b	3	32.5								.38			0.73	33.2
1964	Win	10a	6	8.5	0.5			0.3							0.09	9.3
1964	Win	10b	2	0.3											0.06	0.3
1964	Win	11a	5	13.8	0.5			1.8							0.30	16.1
1964	Win	11b	2	0.3	0.3											0.5
1964	Win	12a	5		0.8	2.5							1.8	0.50	0.26	5.3
1964	Win	12b	2	2.3											1.04	3.3
1964	Win	13a	1												3.29	3.3
1964	Win	13b	2					16.3							0.48	16.7
1964	Win	14a	4	2.8		0.3		15.5		63.8						82.3
1964	Win	14b	3	7.0										0.01	0.03	7.0
1964	Win	15a	2	6.3				0.8								7.0
1964	Win	15b	7	16.0	1.5	17.5							6.3			52.0
1980	Win	1a	13		12.3	1.3		9.8		1.0	76.0		1.0	7.50	0.07	110.8
1980	Win	1b	11	2.5	3.0	1.0			1.5	0.3	58.8		0.8	35.75	0.06	106.1
1980	Win	2a	11	0.5	51.5	2.3		1.5	7.5	1.3	33.8		2.5	38.25	0.08	139.1
1980	Win	2b	13	0.5	22.5	0.5		18.0	16.3	3.0	10.0		8.5	50.50		134.8
1980	Win	3a	9	0.3	68.3			3.0	12.5	0.8	17.0			38.75		140.5
1980	Win	3b	13		37.3	0.8		4.5	2.5	4.5	11.8		0.3	52.50	0.01	115.0
1980	Win	4a	1												96.3	96.3
1980	Win	4b	8		7.0	2.5		0.5	45.0					15.00	0.18	70.2
1980	Win	5a	8		7.3			2.5				.03	1.0	23.75	50.2	84.2
1980	Win	5b	11	7.0	35.5	7.8		14.3						5.00		69.5
1980	Win	6a	7		55.0	3.3			0.3		14.0			23.75	0.02	96.3
1980	Win	6b	9	1.5	23.8			5.5	22.5		25.0			25.00		99.5
1980	Win	7a	11	30.0	2.8	12.8		9.0		1.3				23.75	0.03	79.5
1980	Win	7b	11	0.8	56.8			5.0	25.0		25.0			15.00	0.05	112.0
1980	Win	8a	13	6.0	10.8	8.8		8.0	39.3	2.5	22.5	10	6.3	37.50		151.5
1980	Win	8b	13	2.8	27.8	10.8		15.8	5.8	3.8	13.8	10	3.8	27.00		121.0
1980	Win	9a	13	19.5	50.0	27.5		7.3	5.0	1.0	11.3			22.50		143.8
1980	Win	9b	6		7.5					0.3	65.3			27.50		122.8

Table A-3. Summary of vegetative site factors by station, continued.

			No				Wtl	Shrubs		Broadleaf Trees			Conifers			Tot
Ste	Sea	Stn	Sp	Frn	Hrb	Grs	Sp	0-1	1-5	0-1	1-5	>5	0-1	1-5	>5	Cov
1980	Win	10a	1											36.25	.49	36.7
1980	Win	10b	9	3.8	22.5	6.3			2.5	0.8	21.5		0.3	30.25		87.6
1980	Win	11a	7	1.8	71.5			5.0			1.0			35.00		115.3
1980	Win	11b	7	20.0	55.3	7.0		0.5			61.3		1.3	5.00		150.3
1980	Win	12a	10	1.3	24.0			11.5	10.0		18.8		1.3	4.25		69.8
1980	Win	12b	12		27.3	7.5		2.3	1.3	5.0	15.0			35.00		93.3
1980	Win	13a	9		47.0			3.8	35.0		12.5		3.8	15.00	.15	117.2
1980	Win	13b	9		73.8	2.0			28.8				3.0	30.00		136.8
1980	Win	14a	15	4.3	20.0	17.5		3.0	20.0		20.0			21.25		106.0
1980	Win	14b	9	10.0	75.3		0.8		10.8		15.0		4.5	8.75		124.0
1980	Win	15a	11		68.8	1.3		23.5	21.5	0.3			2.5	13.50		136.3
1980	Win	15b	14	1.3	75.0	5.0		27.5	33.8				12.5	58.75		213.8
1984	Win	1a	7	16.3	5.7	2.0		7.8						56.25		88.0
1984	Win	1b	8		11.5		73.3	8.0	22.5				4.3	36.25		133.3
1984	Win	2a	11	1.3	9.3	0.3	25.0	1.8					1.0			59.3
1984	Win	2b	7		5.0		47.5	1.3		1.3			9.3			68.5
1984	Win	3a	10		14.3	5.0	17.5	2.5					8.8			47.0
1984	Win	3b	12		32.8	1.3	7.5	5.5		0.5			1.5	20.00		69.0
1984	Win	4a	6		11.3		22.5	1.3	35.0				2.5	5.00		77.5
1984	Win	4b	11	2.3	29.0		17.5	3.8	45.0				2.5	11.25		111.3
1984	Win	5a	8	5.0	13.5		0.3			2.5				6.25		27.5
1984	Win	5b	10	2.8	40.8	1.3	1.3		2.5				7.8			56.3
1984	Win	6a	7	2.3	45.0	1.8	6.3						1.3			58.5
1984	Win	6b	12	9.3	17.5	7.5	51.3	0.8	13.8		2.5		1.3		8.0	103.8
1984	Win	7a	13	0.3	15.3	2.8	1.3	1.5	37.5				0.5	43.75		103.0
1984	Win	7b	7	1.5	24.3		5.0		7.5					77.50		116.8
1984	Win	8a	12	6.5	41.8	4.5	1.3	2.5					3.3	24.25		83.0
1984	Win	8b	11		80.8			9.8	1.5		1.3		2.5	14.50		110.3
1984	Win	9a	9		66.3			16.5					3.0	27.50		115.8
1984	Win	9b	9	12.5	49.0	1.3		1.3			21.3		1.3	35.00		121.5
1984	Win	10a	10	2.5	47.0	4.3		11.3	15.0		1.3		1.5			82.8
1984	Win	10b	8	5.0	46.3	7.5		12.5	60.0				10.8	7.50		149.5
1984	Win	11a	8	3.8	33.5	5.0		2.5	2.5	2.0	18.8		5.0	36.25		109.3
1984	Win	11b	3		8.8									27.50		[illegible]
1984	Win	12a	8		32.5	2.5		3.8	26.3	0.8	22.5					88.3
1984	Win	12b	9		51.3	16.3			20.0	0.8	37.5		0.8	7.50		134.0
1984	Win	13a	9		32.8	1.3		5.0	46.3				8.8	2.50		96.5
1984	Win	13b	5		2.0						3.8			76.25		82.0
1984	Win	14a	8	3.8	19.0	0.3		13.8	10.0					7.50		54.3
1984	Win	14b	6		41.3			2.0	48.8				2.5	35.00		129.5

Table A-3. Summary of vegetative site factors by station, continued.

			No				Wtl	Shrubs		Broadleaf Trees			Conifers			Tot
Ste	Sea	Stn	Sp	Frn	Hrb	Grs	Sp	0-1	1-5	0-1	1-5	>5	0-1	1-5	>5	Cov
1984	Win	15a	4		17.8			2.5			7.5			62.50		90.3
1984	Win	15b	3		28.5						50.0			22.50		101.0
1987	Win	1a	8	3.0	19.0			13.8		2.5						38.3
1987	Win	1b	8	1.3	12.0	1.5		13.8		4.0			0.3			35.0
1987	Win	2a	3	16.8	1.0			5.8								23.5
1987	Win	2b	10	1.3	2.0	3.8		25.3		10.0			0.8			43.0
1987	Win	3a	7	2.8	2.5			15.5					0.8	0.25		21.8
1987	Win	3b	8		8.8	1.3		0.3		0.3			2.5			15.5
1987	Win	4a	2	12.5	1.5											14.0
1987	Win	4b	9	5.0	5.8			9.0		0.8			0.5			21.0
1987	Win	5a	6	13.8	3.8			4.8					5.0			27.3
1987	Win	5b	5	0.3		1.3		2.5		15.3	12.5		3.8	5.00		40.5
1987	Win	6a	6	12.3	2.5	2.8		0.5		1.5						19.5
1987	Win	6b	6	9.3	1.5			1.3		7.5						19.5
1987	Win	7a	2	11.3										4.50		15.8
1987	Win	7b	4	10.0	2.8									12.50		25.3
1987	Win	8a	6	17.3	0.5			2.5		2.5						22.8
1987	Win	8b	3	36.3				2.5					1.3			40.0
1987	Win	9a	5	10.0	6.0			6.3								22.3
1987	Win	9b	7	1.3	5.3	3.8		33.5		1.5						44.3
1987	Win	10a	7	0.8	3.0	5.8		0.3		0.3						10.3
1987	Win	10b	5		10.0	31.3				0.3			1.3			42.8
1987	Win	11a	2	10.0	2.5											12.5
1987	Win	11b	9	1.3	5.0			7.0					10.0			23.3
1987	Win	12a	3		3.8			2.5						56.25		62.5
1987	Win	12b	9		17.0	0.3		4.3					2.5	27.50		51.5
1987	Win	13a	6	1.3	9.0	7.5		1.3					0.3			19.3
1987	Win	13b	8	2.5	12.5			5.0		8.8			0.5	7.50		36.8
1987	Win	14a	5	1.3	2.0	6.3		0.3								9.8
1987	Win	14b	2			1.3								70.00		71.3
1987	Win	15a	5	3.8	12.5	6.3		8.0			7.5					38.0
1987	Win	15b	3	8.3				0.8						55.00		64.0
1989	Win	1a	2	10.0	0.3											10.3
1989	Win	1b	2		0.8			5.0								5.8
1989	Win	2a	2	10.0	0.8			5.0								15.8
1989	Win	2b	3	6.3	2.5			0.3								9.0
1989	Win	3a	4	2.5	5.3			2.5								11.3
1989	Win	3b	3	5.0	1.3			3.8								10.0
1989	Win	4a	4		4.0		2.5	0.3								6.8
1989	Win	4b	5		12.8			1.8								15.5

Table A-3. Summary of vegetative site factors by station, continued.

			No				Wtl	Shrubs		Broadleaf Trees			Conifers			Tot
Ste	Sea	Stn	Sp	Frn	Hrb	Grs	Sp	0-1	1-5	0-1	1-5	>5	0-1	1-5	>5	Cov
1989	Win	5a	5	2.8	5.8											8.5
1989	Win	5b	4	10.0	2.5			0.3						12.5		25.3
1989	Win	6a	5	1.8	10.0			1.3						12.5		25.5
1989	Win	6b	5	1.8	0.3			1.3						12.5		18.3
1989	Win	7a	6	22.5	4.5			4.0						5.0		36.0
1989	Win	7b	4		0.3			1.8						11.5		13.5
1989	Win	8a	1													96.3
1989	Win	8b	4	18.8	12.3											31.0
1989	Win	9a	6	4.3	7.8					0.3			3.5			15.8
1989	Win	9b	4	0.8						0.3			10.0	15.0		11.0
1989	Win	10a	7	0.5	2.5	2.5		1.5		2.5				16.3		23.5
1989	Win	10b	1					7.5								7.5
1989	Win	11a	4		0.5			7.5						16.3		17.5
1989	Win	11b	1		1.0											1.0
1989	Win	12a	4	1.3				0.3		2.5				11.3		15.3
1989	Win	12b	10	2.5	12.7		5.0	5.0					0.3	8.8		34.3
1989	Win	13a	5		3.3		0.3	0.5								4.0
1989	Win	13b	6		1.5			7.8								19.5
1989	Win	14a	5		4.0	0.3										4.8
1989	Win	14b	4	0.3	4.0			3.0								7.3
1989	Win	15a	3	2.5		1.5				1.3						5.3
1989	Win	15b	5		4.0			0.3		2.5			3.8			10.5

APPENDIX B-Plant Species and Their Cover Values

Herbs	1989	1987	SITE 1984	1980	1964	Control
Anaphalis margaritacea				0.017		
Asarum caudatum		0.083	0.442			
Cirsium sp.	0.542	0.083	0.017	0.017		
Crepis sp.			0.008			
Erechtites prenanthoides		0.475	0.092			
Fragaria sp.			0.342			
Galium aparine	0.333					
Galium spp.		0.125	0.058	0.033	0.008	
Iris douglasiana	0.275	0.933	1.392	0.892		
Oxalis oregana	0.192	0.008	0.025	0.183	0.108	4.717
Stachys rigida	0.592	0.025				
Viola sempervirens	1.117	0.208	1.350	1.962	0.183	0.108
Whipplea modesta	0.700	3.025	24.817	30.900	0.017	
Unidentified species	0.392	0.258	0.333	0.025		0.042

Grasses	1989	1987	SITE 1984	1980	1964	Control
Hierochloe occidentalis	0.025	0.275	1.075	4.033	0.450	0.400
Holcus lanatus			0.567	0.025		
Unidentified species	0.142	2.225	0.583	0.117	0.083	0.025

Ferns	1989	1987	SITE 1984	1980	1964	Control
Polypodium sp.		0.017	0.117	0.050	0.033	
Polystichum munitum	3.773	6.417	2.300	3.767	4.878	17.592
Pteridium aquilinum					0.025	

Wetland species	1989	1987	SITE 1984	1980	1964	Control
Carex brevicaulis	0.217		0.192			
Cyperis sp.			0.333			
Juncus sp.			8.717	0.025		

APPENDIX B-continued

Shrubs 0 to 1 m	SITE 1989	1987	1984	1980	1964	Control
Arctostaphylos columbiana		0.125	1.183	0.500		
Baccharis pilularis			0.058			
Ceanothus thrysifloris			0.708	0.375		
Cytisus monspessulanis		0.250				
Gaultheria shallon			0.417	1.342		0.125
Lonicera sp.	0.042	0.042	0.192	0.725	0.008	0.017
Rhododendron macrophyllum		0.108		0.375	0.558	
Rubus leucodermis	0.992	2.758	0.183	0.058		
Rubus parviflorus		0.192	0.192	0.083		
Rubus sp.			0.083	0.108	0.608	
Rubus ursinus	0.042	1.025	0.608	1.133		
Vaccinium ovatum	0.283	0.750	0.192	1.392	0.692	1.082
Vaccinium parviflorum		0.333	0.125			

Shrubs 1 to 5 m	SITE 1989	1987	1984	1980	1964	Control
Arctostaphylos columbiana			1.717	7.883		
Ceanothus thrysifloris			11.417	3.875		
Rhododendron macrophyllum				1.192		
Vaccinium ovatum				0.125		

Broadleaved trees 0 to 1 m	SITE 1989	1987	1984	1980	1964	Control
Arbutus menziesii				0.108		
Lithocarpus densiflora	0.233	1.825	0.200	0.817	2.718	0.642
Myrica californica			0.058	0.025		

Broadleaved trees 1 to 5 m	SITE 1989	1987	1984	1980	1964	Control
Arbutus menziesii				0.333		
Castanopsis chrysophylla				0.008		
Lithocarpus densiflora		0.667	5.458	16.075		0.625
Myrica californica			0.083	1.417		

Broadleaved trees >5 m	SITE 1989	1987	1984	1980	1964	Control
Castanopsis chrysophylla				0.333		
Lithocarpus densiflora				0.333	1.995	
Myrica californica				0.001		

APPENDIX B-continued

Conifers 0 to 1 m	SITE 1989	1987	1984	1980	1964	Control
Abies grandis				0.100		
Pseudotsuga menziesii		0.142	1.500	0.942	0.050	
Sequoia sempervirens	0.583	0.842	0.858	0.842	0.225	0.758
Tsuga heterophylla			0.383		0.134	

Conifers 1 to 5 m	SITE 1989	1987	1984	1980	1964	Control
Abies grandis				1.017		
Pseudotsuga menziesii			0.675	9.225	0.000	
Sequoia sempervirens	3.550	7.950	21.367	15.158	0.040	1.678
Tsuga heterophylla					0.250	

Conifers >5 m	SITE 1989	1987	1984	1980	1964	Control
Abies grandis					0.577	
Pinus muricata					4.934	
Pseudotsuga menziesii			0.267	0.003	17.953	37.749
Sequoia sempervirens				6.960	66.038	50.695
Tsuga heterophylla					1.102	4.929

APPENDIX C-Morphometric Data on Small Mammal Species

(lengths are in cm; weights in g)

Chipmunk

		Males	Females	Juveniles
Sample Size		9	11	7
Hind Foot Length				
	Mean	31.44	32.82	31.71
	Std. Dev.	1.51	2.04	1.25
Ear Length				
	Mean	16.22	15.91	14.00
	Std. Dev.	3.63	3.05	2.58
Body Length				
	Mean	108.89	110.91	105.71
	Std. Dev.	6.51	11.36	9.32
Tail Length				
	Mean	117.22	119.55	122.86
	Std. Dev.	4.41	5.68	8.09
Total Length				
	Mean	215.00	212.27	214.29
	Std. Dev.	32.60	40.09	44.67
Weight				
	Mean	106.78	114.09	89.57
	Std. Dev.	36.24	23.26	7.89

Deer Mouse

		Males	Females	Juveniles
Sample Size		94	92	21
Hind Foot Length				
	Mean	19.47	18.92	16.76
	St. Dev.	1.18	1.83	2.39
Ear Length				
	Mean	14.96	14.09	12.95
	St. Dev.	5.13	2.64	3.06
Body Length				
	Mean	69.64	68.37	58.62
	St. Dev.	5.34	6.02	6.55
Tail Length				
	Mean	83.35	81.58	75.29
	St. Dev.	7.89	7.04	7.94
Total Length				
	Mean	152.99	150.20	133.90
	St. Dev.	10.39	10.74	12.29
Weight				
	Mean	20.99	21.71	15.19
	St. Dev.	2.82	4.71	3.39

APPENDIX C, continued

Woodrat

	Males	Females	Juveniles
Sample Size	6.00	14.00	20.00
Hind Foot Length			
Mean	34.83	34.57	33.25
Std. Dev.	2.79	1.28	2.36
Ear Length			
Mean	51.83	26.07	24.20
Std. Dev.	64.41	3.85	2.44
Body Length			
Mean	177.50	155.36	148.60
Std. Dev.	25.45	11.68	18.09
Tail Length			
Mean	192.17	188.29	171.15
Std. Dev.	14.36	22.81	18.07
Total Length			
Mean	369.67	336.50	319.75
Std. Dev.	36.45	35.86	32.15
Weight			
Mean	290.00	237.64	172.95
Std. Dev.	74.63	28.14	40.46

Red-backed Vole

	Males	Females	Juveniles
Sample Size	57.00	36.00	None
Hind Foot Length			
Mean	16.46	16.42	
Std. Dev.	2.30	2.81	
Ear Length			
Mean	10.04	9.72	
Std. Dev.	1.69	1.88	
Body Length			
Mean	84.30	80.89	
Std. Dev.	7.02	8.17	
Tail Length			
Mean	38.63	38.61	
Std. Dev.	3.97	3.92	
Total Length			
Mean	123.07	119.50	
Std. Dev.	8.71	9.43	
Weight			
Mean	27.58	25.61	
Std. Dev.	4.56	5.64	

APPENDIX C, continued

Oregon Vole

Sexes Combined	
Sample Size	7
Hind Foot Length	
Mean	13.29
Std. Dev.	2.50
Ear Length	
Mean	9.25
Std. Dev.	1.50
Body Length	
Mean	79.17
Std. Dev.	7.36
Tail Length	
Mean	75.86
Std. Dev.	114.78
Total Length	
Mean	114.33
Std. Dev.	9.95
Weight	
Mean	23.38
Std. Dev.	2.88

Meadow Vole

	Males	Females	Juveniles
Sample Size	4.00	3.00	None
Hind Foot Length			
Mean	25.50	17.33	
Std. Dev.	9.71	3.79	
Ear Length			
Mean	9.75	9.00	
Std. Dev.	4.99	3.61	
Body Length			
Mean	101.25	93.33	
Std. Dev.	6.29	11.55	
Tail Length			
Mean	45.75	41.00	
Std. Dev.	0.50	6.56	
Total Length			
Mean	145.75	134.33	
Std. Dev.	8.18	14.01	
Weight			
Mean	51.75	41.00	
Std. Dev.	2.87	17.06	

APPENDIX C, continued

Insectivores

Sexes Combined	Trow. Shrew	Pac. Shrew	Shrew Mole
Sample Size	16.00	8.00	2.00
Hind Foot Length			
Mean	11.75	13.00	15.50
Std. Dev.	1.48	1.85	0.71
Ear Length			
Mean	5.50	5.75	•
Std. Dev.	2.13	2.38	•
Body Length			
Mean	48.38	58.13	59.50
Std. Dev.	2.19	8.84	6.36
Tail Length			
Mean	49.56	58.50	42.50
Std. Dev.	2.66	3.12	3.54
Total Length			
Mean	98.81	116.75	102.00
Std. Dev.	3.78	10.99	9.90
Weight			
Mean	4.94	10.38	8.50
Std. Dev.	1.24	3.85	6.36

APPENDIX D-Other Animals Observed

Birds of Prey

Red-tailed Hawk	*Buteo jamaicensis*	Visual
Western Screech Owl	*Otus asio*	Visual
Osprey	*Pandion haliaetus*	Visual
Accipiter	*Accipiter sp.*	Visual
Great Horned Owl	*Bubo virginianus*	Auditory
Northern Spotted Owl	*Strix occidentalis*	Auditory

Other Birds

Turkey Vulture	*Cathartes aura*	Visual
California Quail	*Lophortyx pictus*	Visual
Raven	*Corvus corax*	Visual
Winter Wren	*Troglodytes troglodytes*	Visual
Brown Creeper	*Certhia americana*	Visual
Steller's Jay	*Cyanocitta stelleri*	Visual
Red-shafted Flicker	*Colaptes cafer*	Visual
Band-tailed Pigeon	*Columba fasciata*	Visual

Carnivorous Mammals

Gray Fox	*Urocyonc cinereoargenteus*	Scat
Bobcat	*Lynx rufus*	Scat/Visual
Hoary Bat	*Lasiurus cinereus*	Visual

Herbivores

Gray Squirrel	*Sciurus griseus*	Visual
Black-tailed Deer	*Odocoileus hemionus*	Visual

Amphibians

Pacific Giant Salamander	*Dicamptodon ensatus*	Visual